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Drivers and material pushed to the limit: endurance racing is the ultimate test of durability in motorsports. The year 2023 ushers in a new era for one of the most important and prestigious forms of motorsports with the new prototype class – Le Mans Daytona hybrid (LMDh). Bosch Motorsport is lining up to prove its expertise, endurance, and performance as the supplier of the unified hybrid system.

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INTERNATIONAL RACE TECH Motorsport Engineering

Volume 32 Issue 8
Published June 2025
The next issue will be published in early July 2025
ISSN 1356-2975

**SUBSCRIPTIONS**
Subscriptions from Kimberley Media Group Ltd
841 High Road, Finchley, London N12 8PT
**Tel +44 (0)20 8446 2100**

Overseas copies are sent via air mail
12 issue subscription UK: £71.40
Europe: £118, USA/Rest of World: £149
All major credit cards accepted. Cheques and money orders only in Pounds Sterling payable to Kimberley Media Group Ltd.

**BACK ISSUES AVAILABLE:**
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Price including post & packing:
UK: £5.95, Europe: £6.50, Rest of World: £7.55
You can pay by cheque or credit card but please note the minimum on Switch & Delta is £14

Race Tech (ISSN: 1356-2975) is published monthly by Kimberley Media Group Ltd.

**Cover image:** FIA/WEC/DPPI

**Design & Production:** Paul Bullock

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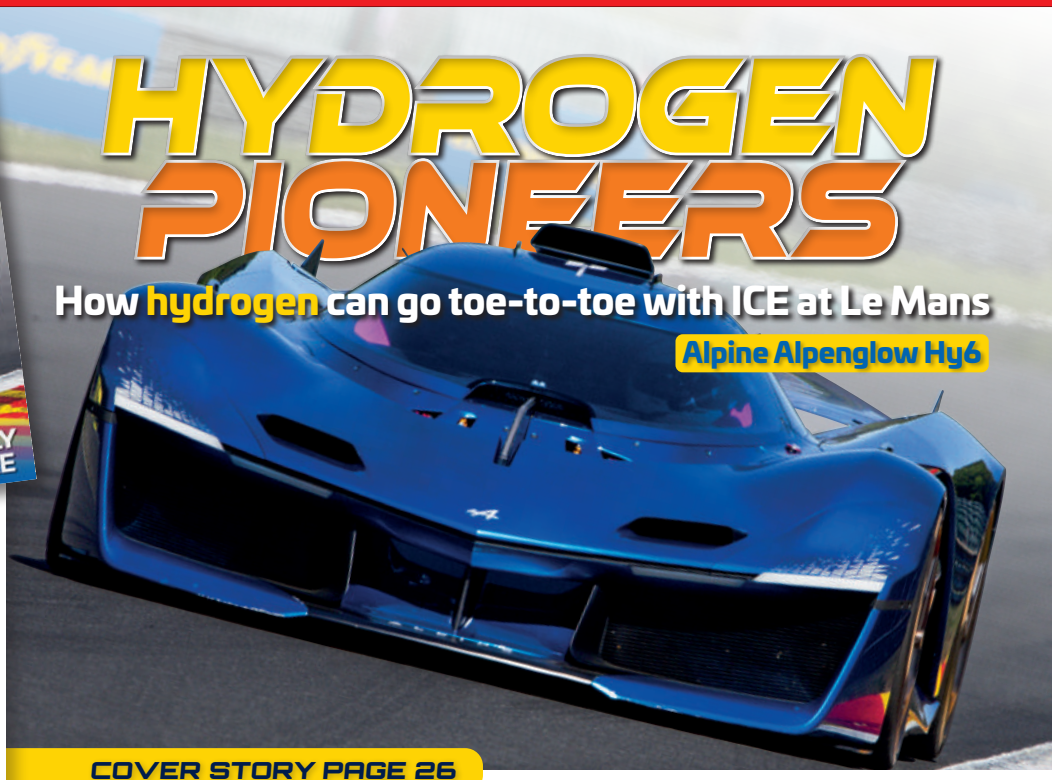


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# Quality & Strength to Go the Distance

The Acura AR24e power unit was developed by Honda Racing Corporation, US to bring electrification to the Precision Crafted Performance of Acura's endurance sports car racing program. The complete hybrid power unit is based around the Acura AR24e internal combustion engine (ICE), an all-new bespoke 2.4-liter, twin-turbocharged direct injection racing V6 that was designed, developed and manufactured by HRC.

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# HOPE OR HYPE?

**IS HYDROGEN** really the future of motorsport? No need to devote an entire column to that one, where one word will suffice. No.

But it may well play a role...

That's why I'd urge you to take a look at this month's cover feature with Pierre-Jean Tardy, chief engineer for hydrogen at Alpine. The F1 veteran offers a refreshingly candid evaluation of the company's experiments with the technology, which will be showcased with the glorious Alpenglow Hy6's demonstration lap at this month's Le Mans 24 Hours.

No amount of hype can mask the fact that the global hydrogen market has not developed as quickly as hoped. Likewise, the grand plans for hydrogen cars slugging it out with ICE rivals for overall victory in the endurance classic have also slipped backward faster than a government policy in retreat.

The breakthrough was originally earmarked for 2024. Now it's 2028. But, as yet, no regulatory framework is in place and there is even talk of the super-successful Hypercar regulations being extended to 2032.

Another embarrassing setback? Far from it: the extension would be a shrewd move, allowing newcomers to the endurance racing goldrush – the likes of McLaren, Ford and Genesis – the opportunity to justify their expenditure.

It would also buy the rest of us the time to enjoy a golden era of racing, not to mention taking the pressure off the talented engineers engaged in the fiendishly difficult task of readying the next generation of hydrogen racecars.

One of the biggest challenges they face is the onboard storage of the hydrogen. The FIA's championing of liquid instead of gaseous technology is probably the only way we can get the stint length required for hydrogen cars to compete with ICE, but it does throw the designers another wicked curve ball.

It's interesting to note that Tardy calls for the liquid storage system to be standardised as much as possible across the cars. Alpine, like Toyota, is happy to fight on engine technology and on aerodynamics, indeed craves the freedom to pursue its own strategies for things that aren't directly performance-related like NOx reduction. Freeing them from the costly complexities of the hydrogen storage system would certainly ease the journey along a path already strewn with perils.

Will the Le Mans hydrogen dream really become a reality? The jury remains out, for any solutions we arrive at surely need mass market potential across other applications? They must be scalable, rather than merely symbolic. RT

Mark Skewis
**EDITOR**

# "Young or old, we want fans to think the new car is cool!"

Mark Sibla, IndyCar's Senior Vice President of Competition and Operations, talks to **Mark Skewis** about the next generation racecar

**INDYCAR'S** next generation racecar will be hybrid and "racy".

That's the pledge of Mark Sibla, IndyCar's Senior Vice President of Competition and Operations, for whom maintaining the series' reputation for good racing is one of the central pillars of the new project.

Dallara, IndyCar's chosen chassis manufacturer, was a trailblazer with its aerodynamic studies to evaluate overtaking, running two scale models together in a wind tunnel long before rival championships. Sibla says that the understanding gleaned from the constructor's work in this area down the years has helped shape the current DW12's replacement.

"IndyCar has become known for the quality of its racing. It's a differentiator," he says. "We've done a lot of work with Dallara to understand trailing cars, wake, the ability for a car to pass – but not artificially! – and we will use all that we've learned on the new car.

"If you've got a dialled-in car but you've qualified at the back, you will have a chance to come through the field. That was one of our priorities with the new design."

With its DW12 chassis now in its 14th season, IndyCar has targeted the 2027 or 2028 campaigns for the introduction of its next car and powertrain. However, the conflict between calls to go for a spectacular, futuristic design yet also the desire to keep costs under control has generated heated debate. Especially when the first renderings of Dallara's proposed design were criticised by some team owners for being too like the current car.

Tino Belli, IndyCar's head of aero development and a veteran designer and engineer in Formula 1, IndyCar and sportscar racing, has been tasked with updating the appearance of the new Dallara chassis.

The Welshman, who joined IndyCar in 2014, was central to the creation of the current Universal Aero Kit that's been in use since 2018. Back in the day when he was poacher rather than gamekeeper, he had a hand in the March 90P, widely praised for its looks.

The word is, according to those who've seen his influence on the upcoming design, that Belli has made an immediate impact. The most recent version of the next-generation car is said to look nothing like the original rendering.

Sibla admits that there has been considerable progress, but reveals that the truth of the story is slightly different to the version proliferating across the media.

"Tino's become very involved in the styling because we want something that, whether it's the younger generation or older fans like myself, people look at and say, 'That's a cool racecar," says Sibla.

"So yes, his role has become far more interactive for a couple of reasons," he explains. "One, he is so talented, has

Penske Entertainment

such a wealth of knowledge that we'd be foolish not to use that; but two, it is also the process for the project: now he has something to react to and to work on with Dallara. So now he can talk more about raceability, fine-tuning aesthetics.

"It was kind of construed as if he was sitting on the sidelines but then all of a sudden was brought in to make this car look better, but I don't think that's fair to him because he was involved from the get-go in creating the very first blueprint and that has expanded as the project moved along."

Belli is part of an engineering triumvirate at IndyCar which has guided the new project from inception, working alongside Darren Sansum (MD of powertrain development) and Bill Pappas (VP of competition and race engineering).

"Outside of those who are in the know, I don't think people give these guys the credit they deserve," says Sibla. "It's a group who are extremely knowledgeable but also genuinely love the sport. When they are looking at things, they are thinking of the key stakeholders, the teams, the fans. They are working very closely with a group at Dallara who also have a special place in their heart for IndyCar, so it's fair to note that we have a very talented collective."

## Go radical?

Sibla utters a rueful laugh when quizzed about the rough reception given to the initial renderings of the new car. Some team owners had a preference for a more radical approach, citing Adrian

Newey's Red Bull X1 creation as a possible route to explore.

"The initial rendering wasn't drastically different, but it was a starting point," admits Sibla. "I often say it's a bit like a logo: I can show somebody and them say that's the most awesome logo ever; I can show it to somebody else and they say it's hideous. We absolutely listened to the feedback and now we have integrated more of that. One comment was, 'How does sponsor branding sit?' So even changing small angles, we can make a big difference. Another was, 'How do we make it more futuristic-looking?' and there's some things we can do there.

"I will say – and it's probably argumentative! – that there was a suggestion it should be very radical. That's where we get into the challenges of understanding that at the same time we have to make it so that it's financially reasonable. And that's not only the initial car, it's what happens when a front wing breaks – how much is that going to cost?

"So it's a multitude of factors and we have made some changes to the design since then based on that feedback."

IndyCar will also introduce its next powertrain at the same time, with Sibla confirming that it will feature a more powerful hybrid system. The current hybrid is superbly packaged in the bellhousing of a car that was conceived long before hybrid technology even registered on the radar of US motorsport.

The extra weight it entails has understandably drawn criticism from the drivers – even though the delta between this year's tyre options is a far more likely culprit for the lack of overtaking in the early races – and weight reduction is another key initiative across the new car.

With a 50 per cent scale model currently undergoing wind tunnel testing at Dallara in Italy, what can everybody expect of the new car when it hits the racetrack later this year?

"You'll see a car that's built to be very racy," promises Sibla. "A car where there is a balance struck between looks versus raceability and performance. You can make it really visually appealing but that's maybe not ideal for hard and close racing. But I think it's turning out really well.

"It will be a car with IndyCar DNA in it – it won't be something like, 'Oh my gosh, this doesn't look even remotely like an IndyCar', but also something that is much more thoughtful in how things are integrated. The aeroscreen, for instance, is a great device but it was placed on a chassis where it wasn't just not a priority, it wasn't even *thought of* at the time the car was devised!

"That's what people will see and hopefully come to appreciate. It's due time for a change..."

**ABOVE & LEFT** Belli is heavily involved in the design of the car that will replace the ageing DW12

# FIA's Principal Aerodynamicist moves on

**A KEY** member of the FIA's aerodynamics team has departed his role ahead of the 2026 rules shakeup.

FIA Principal Aerodynamicist Simon Dodman, formerly of Jordan, Toyota, Lotus and Williams, is to step down from his role.

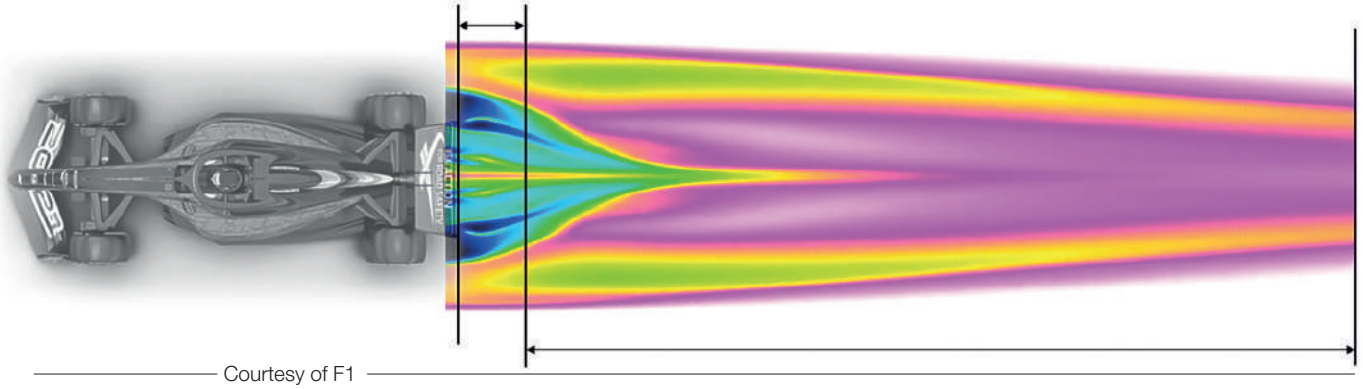
"It's been a privilege to be part of such a talented and passionate team, and I'm immensely proud of what we've accomplished together," he said. "From delivering and overseeing a new era of Technical Regulations to driving forward innovation in CFD, Cloud, ML and Generative AI, it's been an exciting and rewarding journey."

Dodman was part of the team that worked so hard to deliver the latest generation car in 2022, a machine developed with unprecedented levels of research into wake analysis in order to improve overtaking. The car delivered a 30-40% increase in average overtakes per season, a reduction in qualifying grid spread from 2.1% to 1.3%,and resulted in more different drivers reaching the podium positions.

On the technology front, working alongside partners Amazon Web Services (AWS) and Bramble CFD, Dodman has been involved in some groundbreaking work. The FIA has deployed on-demand Cloud CFD that is both infinitely scalable and has halved simulation time, and has rolled out ML geometry optimisers that have streamlined development cycles and shortened time to solution. A recent project necessitated building a Generative AI model that predicts 40 metres of downstream wake in seconds instead of hours.

"These strides have helped shape a more competitive, data-driven future for Formula 1 – and it's been an honour to contribute to that vision," said Dodman. "Thank you to everyone at the FIA and across the wider motorsport and tech communities for the support, collaboration, and inspiration. After a short period on special projects, I'll leave with deep gratitude but massive excitement for what's next."

Dodman is expected to return to working for one of the teams. RT



**BELOW** Legacy CFD wake data was leveraged to train a generative model able to accurately predict a full downstream wake domain from a limited input

Courtesy of F1

# Audi snaps up outgoing Alpine engine partner

**AUDI** has recruited Renault's long-time Formula 1 engine partner, Mecachrome, to assist with its entry to Formula 1 next season.

Mecachrome has been involved in Renault's motorsport engine programmes for over 40 years. It currently assembles and tests Alpine's F1 engine blocks and manufactures some of the parts. Alpine's A424 World Endurance Championship campaign also uses a heavily modified version of Mecachrome's 3.4-litre turbocharged V6 engine that is also used in Formula 2.

Alpine's switch to Mercedes customer engines for 2026 had hit its supply chain hard and the blow was compounded for Mecachrome when the manufacturer elected to take its endurance racing programme back in-house to Viry-Châtillon. The latter will now become the Hypertech Alpine facility which will conduct R&D on cells and new battery chemistries, research new electric motor technologies, host an 'F1 monitoring unit' and assist with a future Alpine Supercar.

Free from its exclusive deal with Renault, Mecachrome has now been enlisted to manufacture some engine components for Audi. It is also said to be in advanced discussions with another F1 team.

Prominent in the aerospace and defence industries, the Mecachrome group has a global turnover of around €600 million and operates across 22 different sites. Its motorsport activities, mainly based at Aubigny-sur-Nère, 170 km south of Paris, account for more than 18% of the company's total turnover.

Audi has also restructured the management of its Formula 1 team for the second time in less than a year. Mattia Binotto, previously chief operating and technical officer, has been made head of Audi F1 project, while chief executive officer Adam Baker has left the company. Audi has also appointed a new chief operating officer, Christian Foyer, to take over the responsibilities on the engine side previously held by Baker. RT

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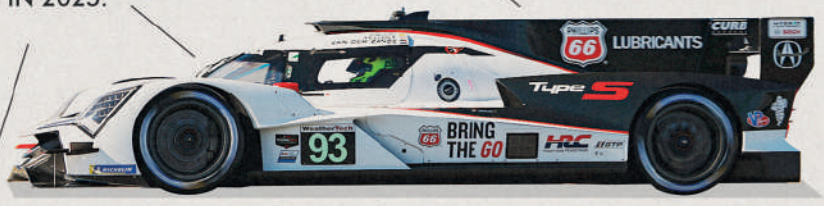


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RACING

# Opel reveals 'electric rally car of the future'

**OPEL** has revealed its vision of what the electric rally car of tomorrow could look like with the new Opel Mokka GSE Rally.

An electric rally car is a tough sell, both from a technical standpoint and in terms of spectator appeal. Nevertheless, the FIA has left the door open for an electric category in its plans for a reimagined World Rally Championship when the current ruleset ends in 2026.

The ADAC Opel Electric Rally Cup 'powered by GSE' is to date the world's only all-electric rally one-make cup and has just started its fifth season. Now Opel has paved the way for the next step by previewing the Mokka GSE Rally, a 207 kW (280 hp) prototype.

"For more than four years, Opel and the ADAC have been demonstrating that electric rallying works and excites," said Opel and Vauxhall CEO Florian Huettl. "With our new Opel Mokka GSE Rally, we are offering a glimpse of a fully electric next generation rally car. Thanks to the latest motorsport technology, the prototype offers strong performance and power aplenty."

The Mokka GSE Rally has an electric peak power output of 207 kW and torque of 345 Nm, promising performance on a par with a Rally4 car. It relies on a multi-plate Torsen limited-slip differential and racing gearbox, together with reinforced driveshafts and wheel hubs. Its Bilstein suspension consists of reinforced MacPherson struts and uniball mounts on the front axle as well as a rigid rear axle with modified springs and dampers.

Electronic driving aids such as ABS, ESP, lane-keep assist and traction control are stripped out of the rally version. The battery corresponds to the production version with a storage capacity of 54 kWh.

**ABOVE & BELOW**
Opel's Mokka GSE Rally is built to the FIA's eRally5 template

Like the Opel Corsa Rally Electric, the Mokka GSE Rally features a special encapsulation of the battery and an additional underride guard. Former WRC hybrid supplier Compact Dynamics has ensured the 400-volt system is continuously monitored by the Master Alarm Indicator. A visual and acoustic warning system immediately reports a malfunction.

In the event of a sudden deceleration (such as in a collision), a sophisticated sensor system completely shuts down the high-voltage system in a few tenths of a second. In addition, the car has a special extinguishing system with electrically non-conductive extinguishing agent.

The Opel Mokka GSE Rally is the first rally car currently being developed according to the FIA's new eRally5 regulations. The prototype could thus be used worldwide in multiple customer sport competitions from the 2026 rally season.

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# Defender tests Rally-Raid prototype

**JLR'S** Defender brand has ramped up its preparations for entering the World Rally-Raid Championship (W2RC) by completing prototype tests in Morocco with the Defender Dakar D7XR.

The squad has also snapped up three stellar drivers: 14-time Dakar-winner Stéphane Peterhansel; talented Lithuanian Rokas Baciuška, a former World Rally-Raid Champion in the T4 class; and American rally driver, motocross champion and four-time Dakar stage-winner Sara Price.

French ace Peterhansel joined the team in Morocco, successfully completing early test activity with the first prototype of the Defender Dakar D7XR. It marked a milestone in the outfit's preparations for competing at the Dakar Rally in January 2026 – an event renowned as the world's most gruelling long-distance offroad race.

Defender will make its works debut at the Dakar Rally, where three Defender Dakar D7XRs will compete in the 'Stock' category for production-based cars. A two-car entry will contest the remaining rounds of the 2026 FIA World Rally-Raid Championship (W2RC).

"Stéphane Peterhansel brings a remarkable amount of practical experience to the team as the most successful Dakar Rally competitor ever. His knowledge is going to be a huge asset to our programme," said James Barclay, Managing Director of JLR Motorsport.

"Rokas Baciuška is one of the most exciting and promising upcoming rally talents. With testing of the Defender Dakar D7XR accelerating, it's a hugely exciting time for the team as we focus on the work that lays ahead."

The Defender Dakar D7XR, the team's purpose-built, production-based competition challenger, will share the same robust D7x aluminium body architecture, transmission and driveline layout as production Defenders. It is powered by a 4.4-litre twin-turbo V8 engine, and the prototype is wrapped in a distinctive camouflage design.

"Competing in the Dakar Rally and W2RC will be the ultimate proving ground for Defender's capability, durability and performance," admitted Mark Cameron, Managing Director, Defender.

The most successful Dakar Rally driver of all time, Peterhansel has competed in the event 35 times on both bike and car. "The World Rally-Raid Championship is the pinnacle of rallying and off-road competition, whilst Defender is an iconic and capable 4x4, so for me it's the perfect match," he said.

"Despite competing in many Dakar Rallies before, both on bike and in cars, I'm looking forward to entering the Stock category, and I'm excited to take it head-on with this team. It's been amazing to get behind the wheel of the Defender D7XR prototype for the first time in Morocco. Whilst it's early days, our testing is moving in a positive direction for our preparation for our Dakar Rally debut in 2026."

The 2026 edition of the W2RC will implement new regulations that are aimed at making the 'Stock' category significantly more competitive overall, as the FIA and Dakar organisers respond to the increasing capacity and popularity of high-performance 4x4s and SUVs.

The build of Defender's official competition cars has also started, with the bodies of the cars coming off the line at JLR's Nitra production plant. An exhaustive test programme is planned before a full team launch later this year. RT

**BELOW** The D7XR prototype tested in the Sahara Desert

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**LEFT** Chester helped transform the airfield into a thriving business hub

# Tributes paid to father who was 'part of Bicester Motion fabric'

**A BUSINESS** owner who helped transform Bicester Airfield into a thriving automotive hub was one of the three victims of last month's fire tragedy.

Dave Chester, a married father of two, had been involved with the Bicester Motion site in Oxfordshire since restoration work began 12 years ago.

The 57-year-old, who ran construction firm Chesters & Sons, was killed along with two firefighters, Jennie Logan and Martyn Sadler, in a blaze believed to have begun in hangar 79.

As investigations continue, Bicester Motion's CEO Daniel Geoghegan paid tribute to the victims and all members of the emergency services who responded to the fire, which at its height was battled by as many as 10 crews. He said that Chester had been an original and integral member of the site's team.

"He had a long history with the estate – indeed from man and boy," said Geoghegan. "He joined us 12 years ago when we first bought the site and, with his wife and two sons, has been a pillar of our whole business community.

"We considered him a member of our team, part of the fabric of our estate and a friend to us all.

"Whenever you had a question, you would 'Just ask Dave', not just him but his whole family as they all cared about this place just as much as we do."

Chesters & Sons was responsible for reinforcing Bicester's original 1926 airfield control tower, which had been in danger of collapse before the work.

"Our whole community used to say that 'Dave always had our back,'" added Geoghegan the day after the fire. "Yesterday, he was doing just that – the epitome of his selfless spirit."

Home to RAF Bomber Command in World War II, the Bicester Motion site now features more than 50 specialist businesses, many focused on classic car restoration and engineering.

Geoghegan described the events as "tragic in so many ways", calling the two firefighters "the epitome of selfless service".

"We extend our heartfelt condolences to their families and loved ones," he said. "They have gone above and beyond under unprecedented circumstances. No words can ever make up for what has happened, but they are all very much in our hearts."

The 444-acre Bicester Motion site began its transformation from the former RAF base in 2013. The first phase, Bicester Heritage, brought dozens of historic car specialists to the business park and an expansion was approved in 2022, aimed at attracting cutting-edge automotive and engineering firms. RT

# Team behind IndyCar hybrid scoops Schwitzer Award

**THE** team that collaborated to develop the IndyCar Hybrid unit was named as the recipient of the 2025 Louis Schwitzer Award.

Sharing a $10,000 prize from the Indiana Section of the Society of Automotive Engineers (SAE) International and award sponsors Cummins and Valvoline Global were Raoul Fernandes of Skeleton Technologies, John Martin of EMPEL Systems Limited, Matt Niles of Honda Racing Corporation (HRC), Darren Sansum of IndyCar, Rupert Tull de Salis of Dana Incorporated and formerly of Mahle Powertrain and Thomas Williams of Ilmor Engineering Ltd.

The introduction of the supercapacitor-based system was a triumph of collaboration, with Honda and Chevrolet – usually rivals on the racetrack – working together to develop and package the hybrid in a Dallara chassis that was conceived long before the technology had entered motorsport's radar.

The system is made up of the low voltage (48V) Motor Generator Unit (MGU) and Energy Storage System (ESS) – consisting of 20 ultracapacitors – both of which fit inside the bellhousing, located between the Chevrolet or Honda internal combustion engine and the gearbox. During regeneration, acting on the clutch shaft, the MGU builds power to be stored in the ESS. The additional horsepower is deployed through the same motor generator on driver demand.

**ABOVE** The hybrid system was a triumph of teamwork

For competition, options for automatic "regen" via braking or throttle position and manual "regen" via selected steering wheel paddles and buttons are available. Deployment of stored energy is only available manually through a latching button, similar to the existing Push to Pass system.

The IndyCar Hybrid unit debuted last July at the Mid-Ohio Sports Car Course and is used at every series race.

Named after Louis Schwitzer, an accomplished engineer and race car driver, the award is a prestigious accolade in the automotive engineering industry, celebrating and recognizing groundbreaking innovations that push the boundaries of automotive technology. RT

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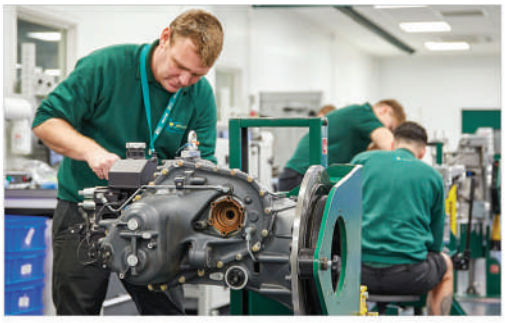

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# Formula E shocked, not rocked, by McLaren exit

**McLAREN's** Formula E programme has become the first casualty of the brand's return to the top tier of endurance racing – but the all-electric race series insists it is in a strong position to ride out the storm currently buffeting the automotive industry.

McLaren announced it would withdraw from Formula E following a "strategic review" and its decision to compete in the World Endurance Championship's Hypercar category from 2027.

Formula E CEO Jeff Dodds admitted that the organization's departure was unexpected but understandable given McLaren's own ambitions – both in racing and with its road car business – and sponsor considerations, with title sponsor NEOM not expected to continue past its current deal.

"I can't sugar coat it, because it's bad news," Dodds conceded. "It was a surprising conversation. I didn't start that day expecting that call, but when it was presented to me, as much as I don't like it, I broadly understand it because I know the types of cars that McLaren Automotive sells today and their pipeline for types of cars they're going to sell for the foreseeable future. I know their sponsorship landscape, and I know what Zak's racing ambitions are.

"It was a difficult call, it was a surprise, but in hindsight there are other brands associated with the championship that would have been a much more surprising call."

Work is underway to find a new backer for the team which, while it runs under the McLaren banner, is effectively an independent operation. Running out of its own headquarters in Bicester just over 62 miles northwest of the McLaren Technology Centre where its Formula 1 team is based, it is currently in its third identity, having started life as HWA Racelab, then morphing into the Mercedes works team before it became McLaren.

"Although our McLaren Racing chapter comes to an end, we recognize the value and power of Formula E as a world championship and platform for positive change as the sport goes from strength to strength," said team principal Ian James. "Work is well underway to explore the best opportunities for the team to continue competing beyond Season 11."

That search for a new backer is not limited just to traditional motorsport OEMS or sponsors, with the net extended to consumer and digital brands.

"The motorsport pool is quite a small pool to fish in and if that's the area we want to fish in, it's highly competitive," noted Dodds. "We're a 10-year-old business, and also our fan base is not typical of motorsport fan bases — it's gender split, it's much younger on balance, and lots of digital natives.

"We're talking with a number of interesting brands that see this as a platform from which they can promote their brand and their brand DNA. As bad as the McLaren news is, it may present a canvas for some of those brands to get in in the way that they want to, that didn't really exist before."

## No cause for alarm

Although McLaren's exit is a high-profile one for Formula E, it has previously bounced back from losing Audi, BMW and Mercedes. The series is in a much better position than it was when the latter of the German trio bade farewell, for it was also an engine supplier. Furthermore, it was seen to be juggling the EV and ICE balls at the same time. McLaren has no such EV portfolio and is itself an engine customer, taking its Formula E powertrains from Nissan.

Dodds underlines that the series is in good health when it comes to manufacturer involvement.

"There are very few motorsports, globally, that have the manufacturer interest we have," he said. "IndyCar, two manufacturers; NASCAR, three manufacturers; Formula 1, four manufacturers. Obviously WEC's had a good run recently, but we currently have six manufacturers in the championship and five of those have already signed up and committed to GEN4.

"And these are not small manufacturers – Porsche, Jaguar, Nissan, Stellantis Group, Yamaha – these are big globally recognized manufacturers, so I think we're in a really good place. I'm sure it was a bad period when the three German manufacturers left, but we have a good foundation for the championship.

"In the relative scheme of things, if you look at motorsport, we're in a really strong place with six manufacturers committed to our championship and five of them already signed up to take us to the end of 2030."

**BELOW** McLaren's withdrawal from Formula E came as a surprise

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# Bosch introduces new liquid hydrogen storage control unit

**ONE** of the biggest challenges in the development of more climate-friendly powertrains isn't just making hydrogen work in the engine, but the supporting ecosystem. Bosch Motorsport claims a breakthrough in this area.

The use of liquid hydrogen is currently favoured as a storage concept in the motorsport segment, following the FIA's championing of this technology. To liquefy the hydrogen, it is cooled to approximately -253°C and filled into the insulated, low-temperature vehicle tanks with a pressure of up to around 5 bar.

In this form, the hydrogen has a higher volumetric density than with alternative gaseous storage, meaning that the tanks take up significantly less space in the racecar.

Hydrogen storage places high demands on the fuel management as well as the safety concept. To facilitate the integration of hydrogen drives into racecars, Bosch Motorsport has engineered the L-HSCU liquid hydrogen storage control unit along with a corresponding safety concept. It can be used to control and monitor the entire storage chain in the vehicle, from refuelling and storage in the tanks to the transfer to the fuel cell or the internal-combustion engine.

## Protective circuits

Sensors supply the control unit with data on parameters such as the pressure and temperature in the tank and fuel lines. Any anomalies in the hydrogen system trigger the automatic activation of protective circuits – for example, fans ensure effective dilution of the gas concentration in the event of a hydrogen leak. The control unit also communicates with the refuelling system both within and outside the vehicle to ensure a safe and efficient refuelling process.

The first use of the L-HSCU liquid hydrogen storage control unit is in the fuel cell-powered H24EVO demo vehicle created as part of MissionH24's program.

"Endurance motorsport offers a perfect testing ground for new technologies since the components employed must be extremely robust and durable," said Ingo Mauel, vice president of Bosch Motorsport. "As an official partner with H24Project, we can contribute both our extensive motorsport experience and our vast hydrogen expertise to the development of the H24EVO and thereby demonstrate that hydrogen is a viable alternative for the world of motorsport."

The hydrogen technology installed in Bosch Engineering's Ligier JS2 RH2 test vehicle will be further developed to meet the specific requirements of high-performance sports cars for the road. Pressurized hydrogen storage is, says Bosch, likely to successfully establish itself in this area, and the group is already working on suitable concepts for the future. The demonstrator will be on show again in the H2 Village at Le Mans this month and will participate in the demo laps for hydrogen-powered racecars. RT

**BELOW** Bosch Motorsport's liquid hydrogen storage control unit will be showcased in the H24EVO

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# IDR landmark for karting safety

**SAFETY** in karting took a significant step at the first round of the 2025 FIA Karting Academy Trophy in Portugal, where all competing karts carried an Impact Data Recorder (IDR) for the first time.

The device, developed by the FIA with the support of the FIA Foundation, was launched globally in 2024, and is a low-cost data recorder that registers key metrics such as impact G forces.

The IDR is aimed at categories from national to regional level where more expensive, bespoke data recorders may not be available. Thanks to its small size (6 cm long) and low weight (12 grams), it is the first FIA-developed accident data recording device to be fitted to a kart – the entry level for circuit racing and the place where every topflight Formula 1 driver began their career.

The FIA's global network of National Sporting Authorities (ASNs) are able to purchase and fit the IDR in grassroots and national competitions. Paired with bespoke software, the devices can provide unprecedented insights into the nature and frequency of crashes, allowing ASNs to adapt and improve their safety infrastructure over time.

The potential for positive change is said to be huge. The data collected from the introduction of the IDR will provide the FIA and by extension organisers of karting events at every level with data that can inform the next generation of integrated safety systems – from circuit layouts to barrier positioning and improvements to safety equipment.

**ABOVE** The rollout of the IDR will gather pace next season

The IDR will be fitted at every round of the FIA Karting Academy Trophy in 2025, with wider uptake expected from 2026 onwards at international and national levels.

FIA Safety Director, Nuno Costa, said: "It was a really successful first implementation of the Impact Data Recorder for karting, which is a discipline that has huge participation but that, up until now, has not been somewhere that we have had a lot of real-world data to draw upon.

"Now, as the IDR is rolled out more widely, the data that is being collected, initially by the FIA and hopefully in the near future also by ASNs, has significant potential to improve safety standards across the board."

Akbar Ebrahim, President of the FIA Karting Commission (CIK), said: "When the FIA launched the IDR, we were immediately very excited about the potential it had to provide a totally new data source in the karting world. The more we understand about the crashes that happen on-track, the better prepared we can be in the future to mitigate risk and protect our competitors." RT

# Genesis Magma Racing working with Dynisma to develop new Hypercar

**GENESIS** Magma Racing has begun working with Dynisma, purchasing one of the company's latest DMG-360XY simulators to aid the development of the GMR-001 Hypercar and preparation for the 2026 FIA World Endurance Championship (WEC).

"Simulator work is key in developing a new car," FX Demaison, Genesis Magma Racing Technical Director, said, "and with the Dynisma DMG-360XY we are working with the best in the business."

The F1-bred DMG-360XY features high stiffness, ultra-low latency, high bandwidth, and unlimited yaw capability, with a five-metre ground plane excursion, providing the most realistic racecar experience possible.

André Lotterer and Pipo Derani, the two drivers currently confirmed for the new team, have had sessions in the simulator at Dynisma's UK base.

"The feedback is immediate and natural," said Lotterer, "it feels like driving the real car. You're not adapting to the simulator; you're getting a 1:1 response that allows you to focus on true vehicle development and performance."

**ABOVE** The new car is already testing on Dynisma's DMG-360XY simulator

"Right now, our focus is on getting used to the simulator and validating the software for the systems," said Derani, "like for example the Hybrid system, MGU and brakes as well as confirming the tyre and car model. The hardware gives us exactly what we need, so it will be essential to the development of the car and our race preparation."

A DMG-360XY will be installed at Genesis Magma Racing's Le Castellet base early in 2026 as part of establishing the team's headquarters.

Demaison said: "The simulator is going to be an important tool when you're limited in testing like we are, because we have a short time to develop the GMR-001 Hypercar but also during next season because the number of test days are strictly limited." RT

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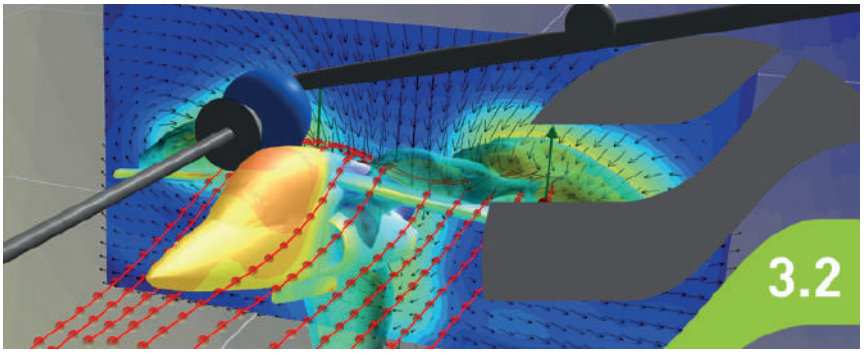
# ProCap 3.2 launched

**THE** latest version of Streamwise's ProCap aerodynamics 3D flow measurement and visualisation system, ProCap 3.2, has officially launched, bringing a suite of powerful new features aimed at enhancing data visualisation, streamlining workflow, and delivering an even more intuitive user interface.

With features designed for both Professional and Compact-version users alike, ProCap 3.2 represents a major leap forward in precision and usability of the already highly intuitive system.

ProCap 3.2 Professional now features surface flow maps. Introducing surface projections enables real-time mapping of measured data such as velocity and static pressure directly onto model surfaces. This new feature provides deeper insight into flow characteristics and significantly enhances analytical capabilities.

The new interface is said to be fast, fluid and fully interactive. Users can now preview changes instantly and make reversible adjustments for a more efficient and intuitive setup experience.




Enhanced data analysis tools include adjustable transparency for model geometries and isosurfaces, as well as improved line rendering for streamlines. These enhancements allow users to create useable images that enable better interpretation of complex flow fields and streamline configurations.

New workflow features include: simplified model positioning; setup cloning; and advanced probe and data handling.

Streamwise ProCap is supplied and supported by Evolution Measurement, whose General Sales Manager, Iain Gordon, said: "The new features had come from ideas discussed by current system users, from a range of industries, who gathered at our recent ProCap User Meeting. Feedback and user experience was gathered and implemented, enhancing this unique system." RT

# IndyCar turns to the Starship

**AS** part of their broader push toward a zero-waste event and reduced operational emissions, IndyCar and Indianapolis Motor Speedway (IMS) announced two new initiatives ahead of last month's Indy 500.

The first is the addition of Shell's Starship 3.0 – a groundbreaking, natural gas-powered transporter – to the series' fleet. It will serve as the new transporter for IndyCar's Pennzoil Tech Inspection Trailer for the remainder of the 2025 season.

Its debut marks a major milestone in Penske Entertainment's long-term sustainability strategy, which includes investments in onsite recycling infrastructure for glass and polystyrene diversion programmes at IMS and an emissions tracking platform for IndyCar, in partnership with NTT DATA.

Shell Starship 3.0 is powered by a Cummins X15N natural gas engine – making it the first natural gas-powered Class 8 truck operating within a national motorsports fleet in North America. With a lightweight, carbon fibre body, advanced aerodynamic design, a mirror-replacement camera system and Shell Rotella natural gas engine oil, the Shell Starship is designed to demonstrate what's possible when cutting-edge commercial freight technology meets environmental responsibility.

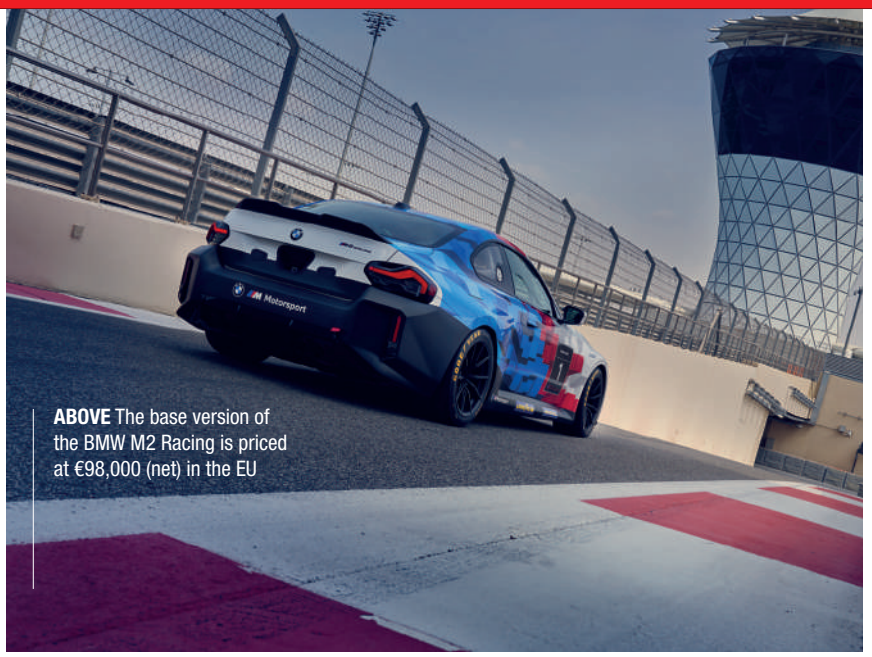
"Integrating Shell Starship into IndyCar's operations is an exciting next step in demonstrating how cutting-edge technologies can support real-world logistics while helping reduce carbon emissions," said Thomas Mueller, general manager of Commercial Road Transport at Shell.

**ABOVE** The announcements underscore the drive for a more sustainable future on and off the track

Natural gas-powered engines, like the Cummins X15N, emit less CO2 than traditional diesel counterparts and can run on renewable natural gas (RNG), a fuel derived from organic waste that's interchangeable with CNG and LNG.

The new emissions tracking software from NTT DATA has been developed in partnership with Penske. The AI-powered emissions management platform will provide IndyCar and its partners with data-driven insights into the carbon footprint of race operations and logistics throughout the season.

The system streamlines carbon accounting – the process of calculating greenhouse gas emissions – by collecting, standardizing and transforming diverse activity data into real-time dashboards and custom reports, offering actionable insights into the size, composition and overall health of emissions data. Shell is among the early adopters of this software. RT



**ABOVE** The base version of the BMW M2 Racing is priced at €98,000 (net) in the EU

# BMW unleashes entry-level challenger

**BMW** M Motorsport has launched its new entry-level racecar: the BMW M2 Racing.

Designed as the successor to the M2 CS Racing, the vehicle has been in development since 2023. It will, said BMW M GmbH CEO Franciscus van Meel, "redefine the entry-level segment".

"With the BMW M2 Racing, we've succeeded in bringing an entry-level customer racing model to the track that combines driving pleasure, performance, and particularly intuitive handling," explained Björn Lellmann, Head of Customer Racing at BMW M Motorsport. "The development was carried out in close collaboration between BMW M Motorsport and experts from series production. The result is a powerful race car that combines easy operation with low running costs."

The BMW M2 Racing is built in the BMW Group's Mexico plant, where the M2 chassis is equipped with motorsport-specific components, including a roll cage. Subsequently, the drivetrain and chassis are pre-assembled with motorsport components.

At its core, the latest M2 features a turbocharged 2.0-litre four-cylinder engine derived from the BMW 2 Series Gran Coupe. This delivers 313 horsepower and 420 Nm of torque, enabling the M2 Racing to achieve speeds exceeding 270 km/h (167 mph). The engine's output is transmitted through a seven-speed ZF automatic transmission.

Equipped with KW shock absorbers and adjustable anti-roll bars at both the front and rear, the package also includes LED headlights, a front splitter, a rear fog light and a lightweight roof. Additional options include a MoTeC C125 data logger, adapter loom and mounting, GPS antenna, endurance brake pads from Endless and a Sabelt GT-PRO driver seat package with adjustable seat rail.

The new racer's test phase used three different cars: a powertrain development mule, a car dynamics development car, and an endurance test car. The latter alone completed 30,000 kilometres.

BMW M works drivers were behind the wheel for the tests, helping optimise performance, drivability and tyre wear. Among them was Jens Klingmann, who said of the new vehicle: "Buyers of a BMW M2 Racing can look forward to a fantastic entry-level car that is very easy to operate, has extremely low operating costs due to its close relation to the production model, and yet is a fully-fledged race car with high performance.

"On the racetrack, the BMW M2 Racing delivers the same driving pleasure that is deeply rooted in the DNA of all BMW M and BMW M Motorsport vehicles. Our focus is to ensure that the BMW M2 Racing, thanks to its characteristics, is the perfect car for everyone – from a novice on a track day to an ambitious racer. And I am very pleased with the result." RT

# WEC Hypercar ruleset could be extended

**THE** World Endurance Championship is poised to cash in on its manufacturer goldrush by extending its existing Hypercar regulations until the end of 2032.

By 2027 the WEC will have lured in no fewer than 11 major players, with Ford, McLaren and Genesis joining Ferrari, Porsche, Aston Martin, BMW, Cadillac, Toyota, Peugeot and Renault-owned Alpine.

WEC CEO Frederic Lequien revealed to Gary Watkins that a follow up to the two-year extension announced at Le Mans last year – which is scheduled to run until the end of 2029 – is now being discussed.

"The only thing I can say is that we must be realistic," Lequien said. "We have something that is working so well, and we will soon be welcoming more manufacturers [Hyundai, Ford and McLaren].

"To not think about extending the homologation would be a mistake. I am not saying we are going to do it, but we are thinking about it."

The Le Mans Hypercar rules commenced in 2021. A second route through which teams could compete, IMSA's LMP2-based LMDh category, began in 2023. The initial five-year rules cycle for LMH was prolonged by two years, until the end of 2027, to bring it in line with LMDh.

The current ruleset was extended ahead of last year's Le Mans 24 Hours when WEC rule makers the FIA and the Automobile Club de l'Ouest firmed up plans for the introduction of hydrogen-powered cars in 2028.

Peugeot Sport technical director Olivier Jansonnie said: "There are new manufacturers entering the WEC in 2027 and them having only three years of racing to try to create some value from the investment they are making is a bit short, so it would all make a lot of sense." RT

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**MARK SIBLA**
Vice President and Chief of Staff, IndyCar

*"Each year, the World Motorsport Symposium brings together a distinguished group of racing experts, each of which is an impactful leader in their field. Their knowledge, insight and transparency on the critical challenges and vision of motorsport make this event essential for industry professionals."*

**BERNARD NICLOT**
ACO's Mission H24 Innovation Director

*"The Automotive World is, with each passing year, more and more difficult to predict. The target is well known: Zero CO2; but the way to achieve it on a large scale is dramatically challenging. In such a period, the World Motorsport Symposium, being so open-minded, is very valuable to share and challenge ideas and solutions not just for motorsport, but for motorsport as a lab for future road mobility."*

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# WHAT THEY SAID...

**DR VALERIA LORETI**
Delivery Manager Motorsport, Fuels Technology Group, Shell Global Solutions (Deutschland) GmbH

*"Participating in WMS 2024 was not only a great opportunity to hear directly from technical experts on a number of relevant and stimulating topics, but also the opportunity for networking and establishing those key relationships that are the basis for further development and exciting breakthrough steps."*

**DAVID SALTERS**
President of Honda Racing Corporation USA (HRC US)

*"I really appreciate the effort that goes into the Symposium, the straightforward open discussion, informed debate and reflection."*

**ERIC JACUZZI**
Vice President, Vehicle Performance at NASCAR

*"Another great learning experience for the two of us that attended from NASCAR. The topics were very relevant to the future of motorsport, and challenged us to look deeper into some areas of development that we had not previously considered or perhaps considered seriously enough. As always, the collegial atmosphere and lively debates and conversations make for a great event. I am looking forward to seeing everyone again next year and hearing about the advancements another year brings."*

**ULRICH BARETZKY**
Former Director, Audi Motorsport Engine Development, Audi AG

*"The 2024 WMS in the famous Royal Automobile Club was very special, a real highlight to mark the event's 20th anniversary. The quality of presentations, as well as the respective discussions in this very special atmosphere, really makes me look forward to the 2025 event."*

**ALAN PATTERSON**
Founder, BeyondMath

*"WMS is the one event that brings together all the leaders in motorsport under one roof. As a startup, this is invaluable for us."*

**SERGE GRISIN**
Motorsport Director, Symbio

*"I was truly impressed by the quality of the discussions, the insightful exchanges with leading experts in motorsport and technology, the spirit of openness and constructive dialogue, and the overall sense of shaping not only the future of motorsport but also, and more importantly, the future of mobility. A future that aspires to be more sustainable."*

# EMISSION IMPOSSIBLE

Pierre-Jean Tardy tells **Chris Pickering** about Alpine's hydrogen combustion-powered Alpenglow prototype, one of the trailblazers in the Le Mans 24 Hours hydrogen revolution

**THE** Alpine Alpenglow Hy6 is the epitome of the modern hypercar concept. Broad haunches, swooping curves, jaw-dropping presence. It's the sort of thing that you might see under the spotlights at the Paris Motor Show or wheeled out onto the Concept Lawn at Pebble Beach.

Except this isn't just a styling exercise dreamt up on a designer's sketchpad. It works. And perhaps equally surprisingly, it's not powered by some silent and soulless electric motor, but by a 740hp V6 that revs to a sonorous 9,000rpm.

The key ingredient here is that the Alpenglow Hy6 runs on hydrogen. It remains a demonstration vehicle rather than a fully-fledged racing car, but the Hy6's twin-turbo six-cylinder engine brings that possibility a significant step closer than its four-cylinder predecessor, the Hy4. It's also an in-house design from Alpine, whereas the engine in the Hy4 began life as an Oreca project before a deal was struck to use it in the original Alpenglow.

Meanwhile, Alpine's road car operation has been rapidly moving towards battery electric powertrains and parent company Renault is investing in fuel cell technology for its cars and trucks. So, why hydrogen combustion for the Hy6?

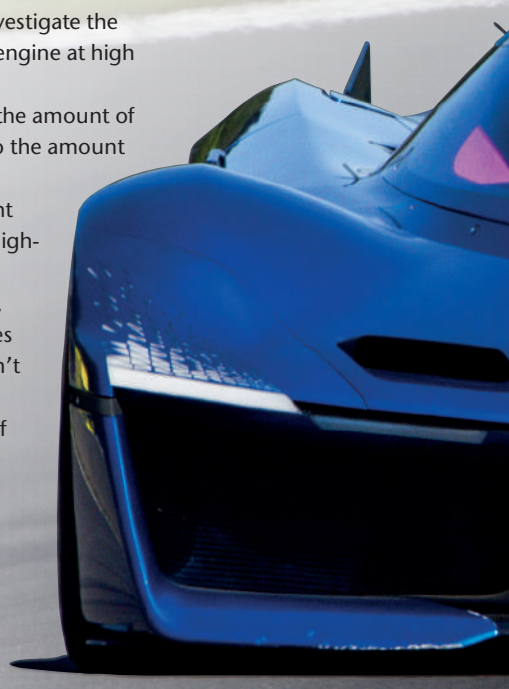
"We believe that the future will be a mix of different technologies, including fuel cells, battery electric and e-fuels. But for Alpine, which is more on the sporting side, we are very much aware of the necessity of having an emotional dimension to our powertrains. The sound of an internal combustion engine is a part of the drama in a race, and it's also a big part of the pleasure for customers driving a sports car. Hydrogen is a way to deliver that with almost no emissions," explains Pierre-Jean Tardy, chief engineer for hydrogen at Alpine.

Tardy has worked at Alpine's Viry-Chatillon base since 1995 when it was still called Renault Sport before its rebranding as Alpine in 2021. He has worked for the Renault F1 team in a variety of engineering positions, covering both the combustion engine and the hybrid system.

"Another thing to consider is that fuel cells are extremely efficient at low loads, but that decreases at high loads – which is the opposite of a combustion engine. There is a point on the graph where the two lines cross and it becomes more efficient to use a combustion engine. So our role is to investigate the potential of the hydrogen combustion engine at high load and high revs," he continues.

As the efficiency of fuel cells trails off, the amount of heat rejection goes up in comparison to the amount of useful energy that they deliver. Tardy points out cooling is already a significant challenge with fuel cells as there is no high-temperature exhaust flow.

"With an internal combustion engine, around a third of the heat rejection goes straight out of the exhaust and you don't need to worry about it," he comments. "With a fuel cell, almost 100 per cent of the heat has to go out of the radiators. What's more, they only run at about 80 deg C so there's less temperature difference to the ambient air, which means you need a bigger surface area for the coolers than you would on a combustion engine with the same heat rejection. That's tricky to package and it significantly increases your cooling drag."



## Stable combustion

Like most hydrogen combustion engines, the previous Hy4 unit was adapted from a gasoline design. The V6, on the other hand, has been designed from the outset as a hydrogen engine.

"With this engine, we used all the knowledge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> *"At Alpine we are aware we need to have an emotional dimension to our powertrains"*

and simulation methodologies that we have developed for Formula 1 to optimise the combustion chamber, intake and exhaust systems specifically for hydrogen," notes Tardy.

One of the key challenges around hydrogen is that it ignites easily and can burn over a very wide range of air-to-fuel ratios, with a hydrogen concentration ranging from 4 per cent to 75 per cent. So, while some degree of combustion is easy to achieve at light loads, it is prone to issues with abnormal combustion. These problems become particularly prevalent when you're running at high loads.

The first priority in the combustion chamber design is mixture preparation, Tardy explains. A lot of CFD work went into the mixing between the hydrogen and the air. This is a challenge shared with gasoline engines, but it is compounded here because the hydrogen enters the cylinder at very high speeds through the direct injection system. As the hydrogen reaches the end of the injector nozzle, it's already travelling at the speed of sound; once into the combustion chamber it's going supersonic, and even generating its own tiny shockwave. This means the design of the injector nozzle is extremely influential in the mixing process.

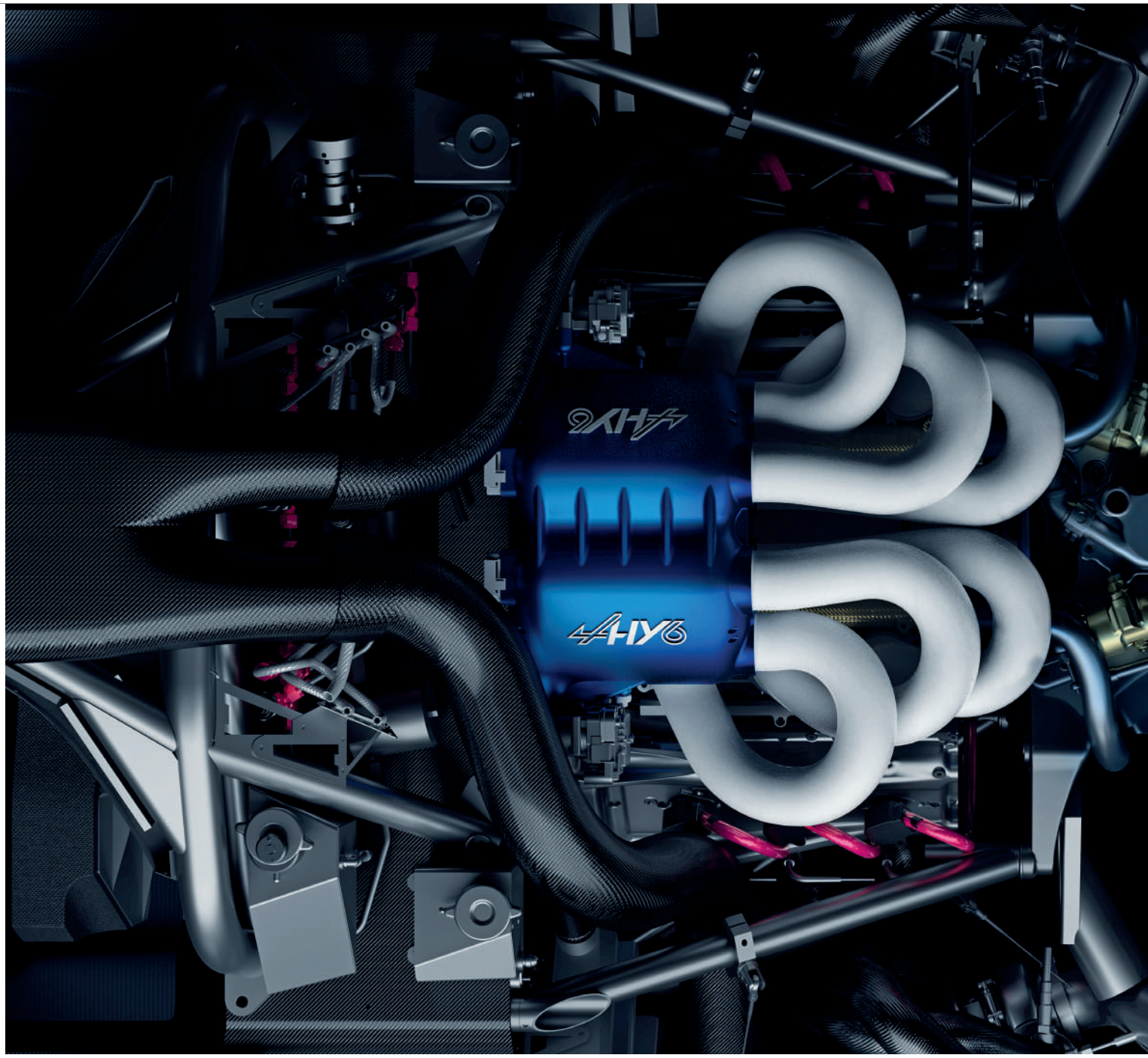
Another challenge is that hydrogen's auto-ignition energy is very low compared to gasoline. If there are any hot spots in the combustion chamber it can lead to pre-ignition or knock.

Hydrogen has the highest specific energy (i.e. energy content per unit mass) of any fuel – almost three times that of gasoline. However, its density (mass per unit volume) is an order of magnitude lower, which means that its energy density (energy per unit volume) is too, even when both fuels are in their liquid state. Hydrogen's low density poses an obvious challenge for storage – more on that in a minute – but it also creates issues inside the cylinder.

"If you have a fuel with a very low density you need a very high volumetric flow rate to get enough into the combustion chamber within the time window – especially if you want to rev high," comments Tardy. "One way to increase the flow rate is to increase the size of the injector, but that can become difficult as you're limited by the ▶

**BELOW** The Alpine Alpenglow Hy6 in full flow on a demo run at May's Spa 6 Hours

Julien Delfosse/DPPI



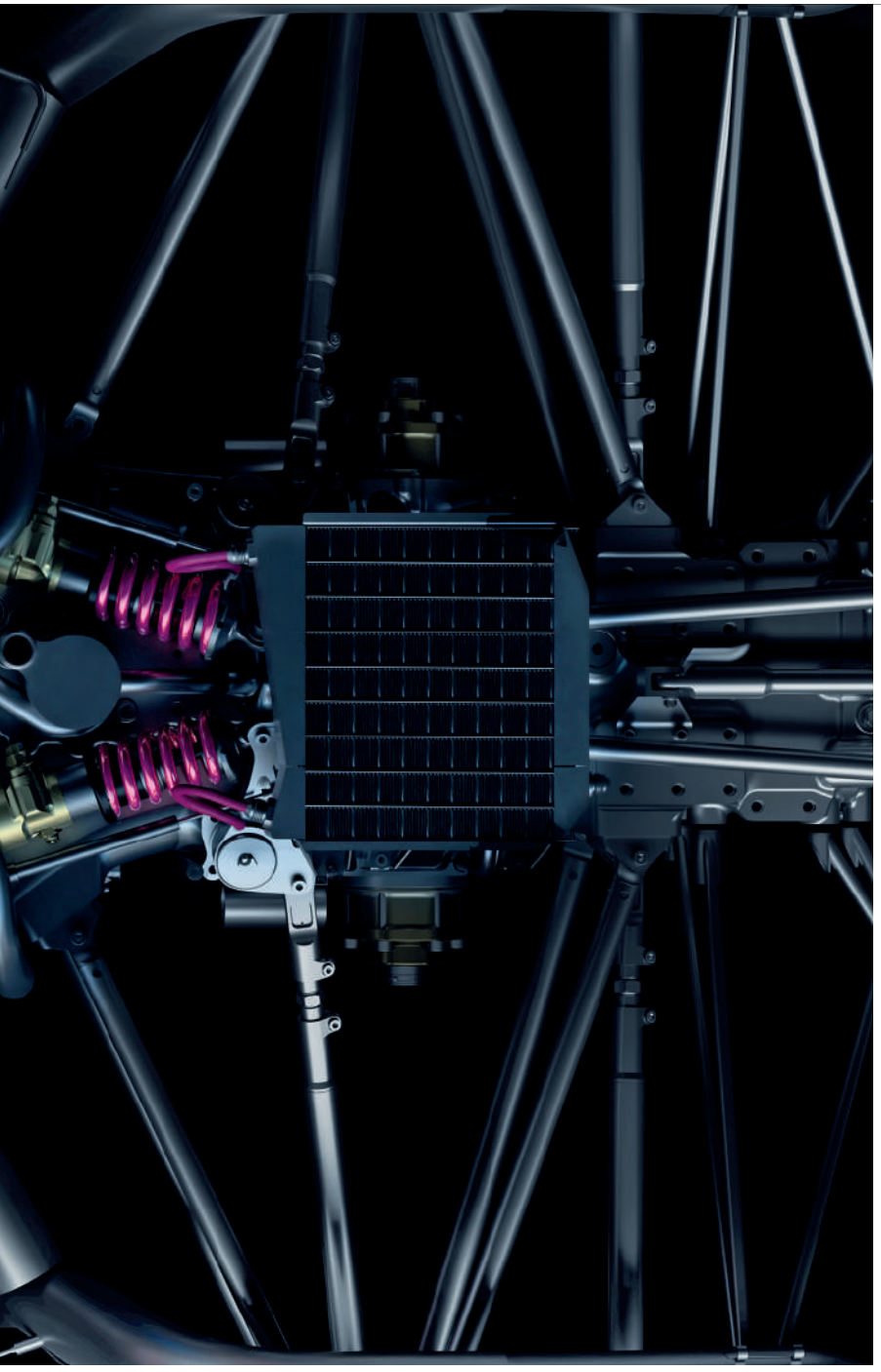

space inside the combustion chamber. So, increasing the pressure is a good way to increase the flow rate as well as improving the mixture preparation."

## Playing it clean

Another key topic for high performance hydrogen combustion engines is turbocharging, which partly comes down to emissions considerations. Although burning pure hydrogen produces zero carbon emissions at the tailpipe, the nitrogen and oxygen in the air will still combine to produce NOx if the temperature is high enough. The principle is much the same as NOx production in a gasoline or diesel engine, but hydrogen has the added challenge that it typically burns far hotter.

There is an argument that NOx emissions are less critical than greenhouse gas emissions, as NOx breaks down naturally over time and only tends to pose a risk in the immediate area. In that sense, it could be seen as less destructive than greenhouse gases, which have a long-term and potentially irreversible impact on the planet as a whole. Nonetheless, high levels of NOx can be very harmful to human health, and it's a problem that the automotive industry is particularly sensitive about following the Dieselgate scandal. As such, reducing NOx emissions is seen as a key target for hydrogen combustion engines across the industry.

"We believe that the work we are doing in racing is a perfect laboratory to accelerate the technology of future mobility. As long as the technical regulations are designed properly, motorsport has the potential to find solutions that could be passed on to passenger cars. And because of that, we're keen to have some regulation around NOx emissions in [hydrogen] motorsport. To be honest that will be quite a challenge, but I think it's a good



engines very lean reduces the peak temperatures, which significantly reduces NOx, and it can also improve thermal efficiency. Other methods are to reduce the flame temperature with water injection or EGR. Alpine is looking into all of these options, and that's where we come back to the importance of turbocharging.

"If you want to run very lean, you need lots of air on the compressor side of the turbocharger. That means you need to supply more energy to the turbine side too, and there you can run into a mismatch, because lean combustion reduces the exhaust temperatures. They can drop to well under 500 deg C, which is even less than a diesel engine. You run the risk of having less energy going into the turbocharger through the turbine, just when you need it to supply all that air," comments Tardy.

This isn't an insurmountable problem, but it does mean that careful thought is required on the design of both the compressor and the turbine. It also means that powertrain engineers need to think of ways to overcome transient response issues such as lag. Alpine is looking into various options to tackle this, including the use of an F1-style heat energy recovery system (MGU-H) to harvest energy that could be used to assist the turbocharger.

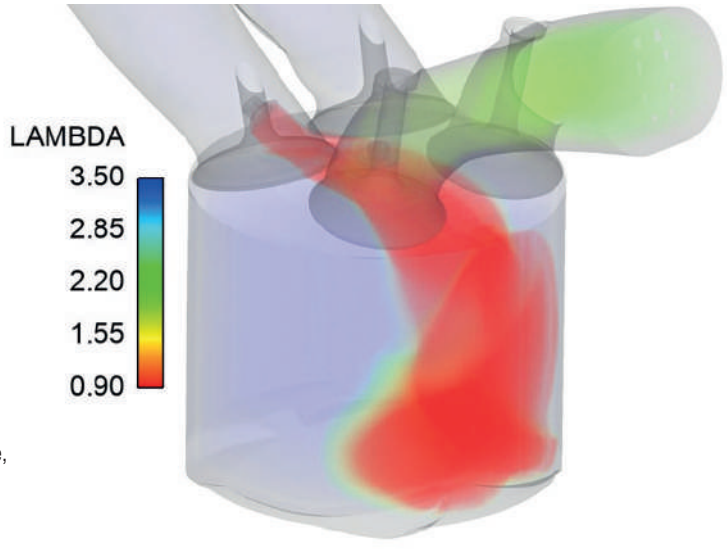
Careful attention also needs to be paid to selecting the right materials for components that come into contact with hydrogen. The gas molecules are so small that they can diffuse into the structure of some metals, causing embrittlement, which can lead to failure. However, there are some materials, including various grades of stainless steel, which are already known to resist this effect. Additionally, there are coatings that can be used to prevent or delay the ingress of hydrogen. Overall, Tardy says, it's not a major challenge for a racing engine, which only needs to provide a relatively short lifespan. Something like a large marine engine, where the lifespan might be measured in decades, poses a far greater challenge. ▶

challenge," comments Tardy.

On the road, some gasoline engines and almost all modern diesel engines use a selective catalyst reduction (SCR) system to reduce NOx emissions, but this isn't an ideal solution in motorsport, he notes: "In racing, we want to avoid the use of aftertreatment systems if at all possible, because they add weight. They also add back pressure, which is bad for both performance and efficiency, so we've been exploring other ways to reduce NOx emissions on the hydrogen engine."

In-cylinder temperatures, and hence NOx production, are strongly dependent on air-to-fuel ratio. Running hydrogen

**ABOVE** Alpine's 740hp twin-turbo six-cylinder Hy6 engine revs to 9000rpm – a major step forward from its four-cylinder predecessor, the Hy4




**RIGHT** CFD of the hydrogen injection phase, with lambda referring to the air/fuel ratio

## Liquid future

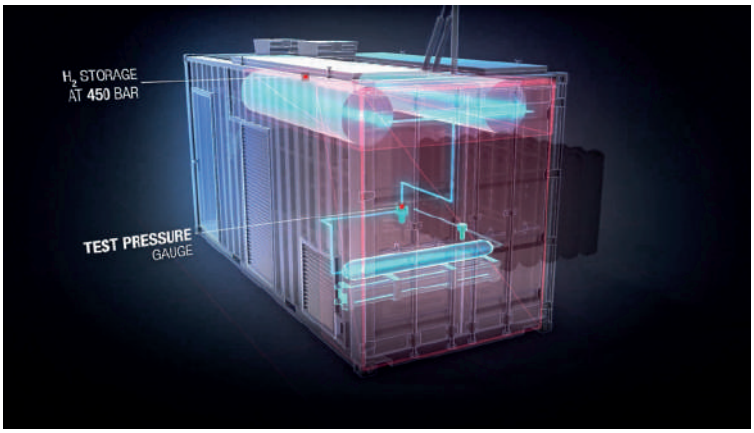
Perhaps the biggest challenge of all comes with hydrogen storage onboard the car (and indeed the associated infrastructure).

The FIA has made it clear that it sees liquid hydrogen as the long-term solution for motorsport and it's a view that's shared by Alpine.

"We were very keen from the beginning that it should be liquid hydrogen. There are many reasons for that. One of them is density. At 700 bar, you get about 40g of gaseous hydrogen per litre of storage, whereas pure liquid hydrogen at ambient pressure is worth 70g/l. In reality, you need to have some gaseous hydrogen in the tank, so a realistic target is more like 60g per litre, but that's still a 50 per cent increase on gaseous storage," explains Tardy.

While high pressures are the key to compressing gaseous hydrogen into a manageable volume, liquid storage relies instead on very low temperatures (below -253 deg C). This brings its own challenges in terms of thermal management and materials compatibility, but it has the key benefit that the hydrogen can be stored at much lower pressures (circa 3 bar).

Low pressure storage greatly simplifies the structural requirements on the tank, allowing designers to package complex shapes rather than the limited range of pressure vessels that can be used at 700 bar.




A significant challenge with gaseous storage is the temperature change that the hydrogen undergoes during refuelling. Coming into the pits with the tank almost empty, a gaseous system might be down to -40 deg C, but that could soar to +80 deg C as the tank is pressurised during refuelling. Ultimately, the speed of gaseous refuelling is then limited by the safe temperature range of the tank. Alpine estimates that ▶

**ABOVE & BELOW**
With the hydrogen ecosystem evolving quickly, TotalEnergies' mobile refuelling station is making the Le Mans hydrogen dream a reality

Julien Delfosse/DPPI

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Javier Jimenez/DPPI

it would take more than two minutes to fill a tank with 15kg of gaseous hydrogen, but less than half that time if you were using liquid.

Using liquid hydrogen brings its own safety considerations, but the low pressure storage could be a major advantage here too, Tardy points out: "In motorsport there's always the risk of a crash, and if a gaseous hydrogen tank is damaged there's the risk of a blast effect, which would be much more dangerous than liquid hydrogen catching fire. Of course, any energy storage comes with risks. A gasoline tank can be dangerous; a lithium-ion battery can be dangerous. But safety with liquid hydrogen is manageable as it has been proven for a long time in different fields of the industry."

> *"We think 15 or 16kg of hydrogen would be enough for a 10-lap stint at Le Mans"*

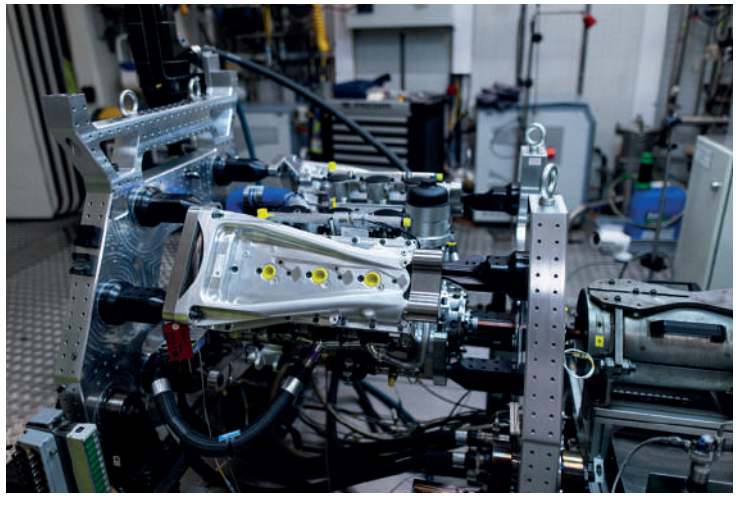
The downsides to liquid hydrogen storage largely revolve around the temperature. As soon as the temperature exceeds -253 deg C, the liquid will start to evaporate into gas. This process is known as boil-off and a small amount of it is virtually inevitable.

"All the advantages point towards liquid hydrogen for racing, but it would not be the same decision for road cars. Liquid storage only really makes sense in a situation where you plan to use the fuel over the next few minutes, hours or days. It's not something that would be practical in a road-going sports car that might only be used a few times each month, because once the liquid starts to boil you need to expel the excess gas to prevent pressure building up in the tank," explains Tardy.

The best way to mitigate this problem is to insulate the tank. In theory, a double-skinned tank with a vacuum layer would be the best option, but Tardy and his colleagues believe that maintaining sufficient vacuum in a racing car could be tricky. As such, they are investigating ▶

**ABOVE** The hydrogen combustion experiments with the Alpenglow – shown on a 2024 demo run – could herald a new dawn for the Le Mans 24 Hours

**BELOW** The core of the Hy6 - without exhausts, intake or ancillaries - on the dyno at Alpine's Viry-Chatillon base



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alternative options that may be simpler.

"The advantage that we have in racing is that we are generally know that we are going to use the fuel in 40 minutes or perhaps one hour, so our requirements for insulation aren't as extreme as they might be in other applications. We can potentially compromise slightly on that side if it makes the tanks easier to manufacture," he notes.

Tardy foresees the use of a heat exchanger to convert the liquid hydrogen into a low-temperature gas almost as soon as it leaves the tank. This would be beneficial for combustion, as well as alleviating some of the thermal challenges around the fuel lines. However, it still needs to be compressed for the fuel injection system, which requires a high-pressure pump capable of operating reliably at extremely low temperatures. This is one of the major challenges that manufacturers will have to overcome if they want to bring hydrogen cars to Le Mans in 2028, but it's by no means impossible. As Tardy notes, Toyota has already campaigned a modified production car running on liquid hydrogen in Japan.

Lubrication is another pressing issue. At -253 deg C, the only materials that won't be frozen solid are hydrogen and helium. This means that the only way to lubricate the components is with the hydrogen itself.

> *"Liquid storage might not be best for road cars but it could be relevant to trucks and even aircraft"*

"Even in liquid form, hydrogen is not a very good lubricant, and it's worse still as a gas," comments Tardy. "It's something we will have to consider in the high pressure pump and also in the injectors. The impact [in the injector] between the pintle and the seat can be quite severe. You always have the problem of friction to deal with, as well as keeping it sealed when it's closed."

Again, there are plausible solutions to these problems, but they represent a huge challenge compared to engineering a car using well-proven gasoline technology.

**RIGHT** Alpine's 'conventional' Hypercar scored its first podium of the 2025 season at Imola

**BELOW** The Alpine Alpenglow Hy6 laps Spa, where a hydrogen village was set up in the Fan Zone to display prototypes and concepts of hydrogen-powered racing cars

Javier Jimenez/DPPI

Fabrizio Boldoni/DPPI

"As engineers, we like to have these kinds of challenges to fix. Of course, it's also a source of stress, because there are some problems that occur that you are not prepared for initially. For instance, one thing we came across was the behaviour of the ceramic material in the spark plug when it comes into contact with the byproducts of hydrogen combustion like steam. It's a fascinating challenge, but it also makes you scratch your head at times."

Once these challenges have been overcome, he believes it will be possible to match the current hypercar stint lengths at Le Mans with hydrogen: "You will need more room in the car. But we think that 15 or 16kg of hydrogen, which equates to about 300 litres, would give you enough capacity for a 10-lap stint at Le Mans, which is what the gasoline cars are doing. That's definitely doable, but the challenge will be keeping the cars small enough – hopefully the same sort of size as the current cars [which typically have a 75 to 90-litre fuel tank]."

The current pace also seems achievable, he says: "If we wanted to match the times of today's LMH and LMDh cars we would need a little bit of hybrid assistance, but not necessarily much more than the current cars."

## Spec components

The complexity of a hydrogen powertrain will certainly pose a formidable challenge. Engineers will have their work cut out just to deal with the key performance differentiators on the car, and Tardy is keen to see some degree of standardisation to ease the workload elsewhere – following a similar philosophy to the standardised hybrid systems seen in LMDh and other categories.

"We would strongly like to see the liquid storage system being standardised as much as possible across the cars. That's our opinion at Alpine, and it's the opinion at Toyota as well," he comments. "We want to fight on engines, on aerodynamics, on driving ... but not on the hydrogen storage system. We already collaborate on these technologies. They are very costly to develop, but they are not part of our core business."

However, he stresses that the engineers would like to see a reasonable degree of freedom on the design of the engine – partly to allow technical competition between the various marques, but also so they can pursue their own strategies for things that aren't directly performance-related like NOx reduction.

One interesting suggestion is that a NOx sensor – similar to those employed on diesel production engines – could be used to enforce an emissions limit in real-time, similar to the use of torque sensors in LMH and LMDh. This would prevent any concerns over the air quality emissions of the racing cars themselves, but it could also make the hydrogen technology more relevant to other applications.

"I think there are plenty of opportunities for the hydrogen technology used in motorsport to be applied to other areas. Liquid storage, for example, might not be the best option for road cars, but it could be relevant to trucks and potentially even aircraft. The reason a lot of the companies that we work with on this project are motivated to get involved is that they can see very rapid results on technology that might have mass market potential in other applications."

All of which brings us to the question of whether Alpine might compete at Le Mans with a hydrogen car in 2028.

"My job is to get the technical bricks ready to go if we make the decision. But no decision has been made either way, and I don't think there will be until maybe the beginning of 2026," comments Tardy.

Of course, hydrogen has already had a somewhat troubled gestation at Le Mans. It's by no means guaranteed that the planned hydrogen category will even materialise. What is clear is that the engine in the Alpenglow Hy6 is not just a flight of fancy, but the product of a detailed engineering study that already extends into topics like liquid hydrogen storage and race refuelling. If a group of manufacturers *do* turn up at Le Mans with hydrogen cars, we'd put money on Alpine being one of them. RT

Charly Lopez/DPPI

**ABOVE** MagCanica's torque sensors are mandatory in the leading LMH class of the World Endurance Championship, pictured storming up Eau Rouge at May's Spa 6 Hours

# TORQUE SENSE

**Chris Pickering** learns how MagCanica's torque sensors became must-have accessories in the world's biggest motorsport series

**MAGCANICA** president Sami Bitar has a neat trick for demonstrating the principle behind his firm's wireless torque sensors.

"You see this thing, and you just think: 'Wow, I didn't know that was possible'," he enthuses, producing a device that looks a bit like a pair of pliers.

He squeezes the curious object with his hand, whereupon it becomes a strong magnet, capable of picking up a steel drill bit on his desk. As he releases his grip, the drill bit falls away – the magnetism apparently destroyed.

Except, the magnetic field hasn't actually gone. The steel shafts connected to its handles are permanently magnetised with circular fields that run down the inside of each shaft like a coil. Normally, the magnetic field remains within the boundaries of the material and is not detectable externally. When the handles are squeezed, however, a twisting force is applied to the shafts, which causes the shape of the field to change. It doesn't grow any stronger or weaker overall; but it creates an axial component that now extends beyond the boundaries of the material.

This is all thanks to a peculiar property of several steels known as magnetoelasticity. Magnetoelastic materials change their magnetic properties in response to mechanical stress (in much the same way that piezoelectric materials change their electrical properties). It's a neat parlour trick, but it's also hugely useful when you want to measure mechanical stress without physically touching an object. And it just so happens to apply to the family of steels that are commonly used for high performance driveshafts.

As any first-year engineering student will tell you, there's a simple relationship between shear stress and torque:

$$Torque = \frac{Torsion\ constant}{Radius} \times Shear\ stress$$

So, armed with a little information about the size and shape of the shaft, it's possible to determine the torque very accurately from the shear stress, which can be measured directly from the strength of the axial component of its magnetic field.

This is not the only way to remotely measure torque, but it has become the dominant solution in motorsport, with MagCanica now the official supplier to IMSA and the World Endurance Championship, not to mention various teams in Formula 1 and beyond.

The story of how this came about goes back to the late Nineties when Bitar was working at Ford Motorsport and set out to investigate various options for torque measurement. It was an idea that he decided to pursue when he left Ford to co-found MagCanica.

"There are basically two approaches to measuring torque in a shaft," he explains. "One is to measure the physical displacement (the strain) using something like a strain gauge, a surface acoustic wave or a dual encoder system and then use this to work out the stress.

"This often requires something to be physically adhered to the shaft, which presents some small benefits but also some major drawbacks, especially if the shaft is spinning at very high speeds and you don't want to risk a failure of the sensing element due to vibration. You also need to add some form of inductive coupling to get power to the shaft and some form of telemetry to transmit the measurement back. So, it soon becomes quite a convoluted process."

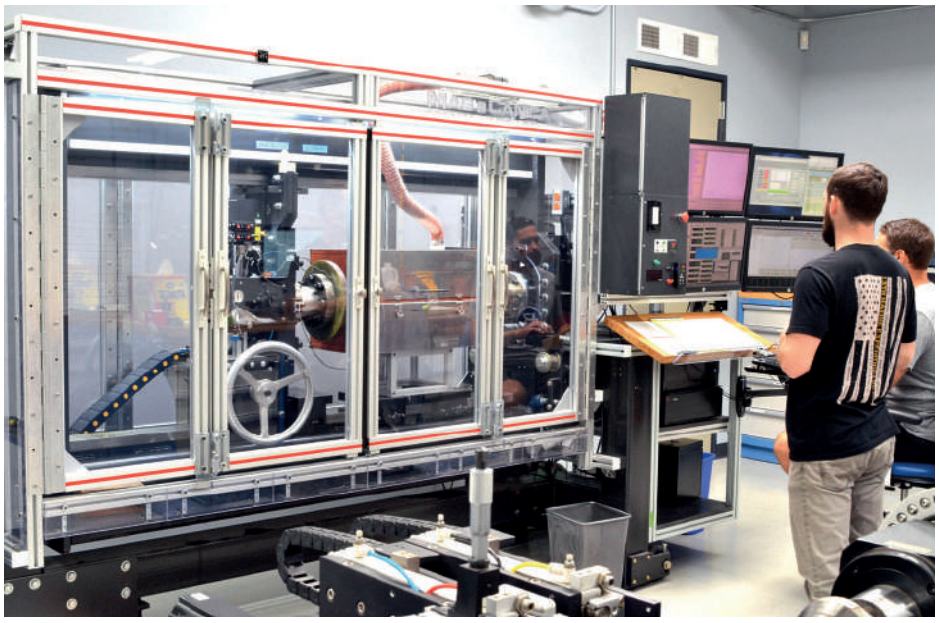
A more fundamental issue, Bitar points out, is that the relationship between strain and stress (and hence torque) is not entirely repeatable.

"The dirty little secret about most traditional torque sensors is that they have a high degree of temperature variation, based on the fact that Young's Modulus of Elasticity is actually quite temperature dependent," he notes. "The other thing is that they rely on a degree of compliance, so there's an intrinsic trade-off between the ability to measure torque with a fine resolution and how much that shaft happens to twist, i.e. deform.

"In a lot of applications where you might want to use this technology you don't have that twist. As it happens, racing shafts twist a lot. But they can actually twist so much that they plastically deform, which presents its own problems with strain measurement."

The other approach is to look at the stress directly. Stress is a measure of force per unit area and it is theoretically less affected by temperature and other physical properties – while allowing for measurement of torque on stiffer shafts. To Bitar and his colleagues, this seemed the obvious way to go.

At the time, the only solution on the market was ▶



## F1 origins

MagCanica was formed in 2000, at a time when Garshelis had the aim of using the system to measure the torque being applied to electric power steering systems. Very soon, however, the focus switched to powertrain and transmission applications.

"We quickly realised that one of the key benefits of this technology was that it was suitable for use in harsh environments and at high rpm, where traditional methods would struggle," explains Bitar. "You can stick a strain gauge on a steering column and the wire might have to wind around a few times, but it will still work fine. You can't do that on a driveshaft spinning at thousands of rpm."

The first practical demonstration of the technology came in 2001, when it was used on the dyno for Toyota Motorsport's

what's now referred to as a Type 1 magnetoelastic system. Like MagCanica's system, this works by measuring how the magnetic behaviour of a material varies in response to the stress that's applied. However, these systems typically worked by running the shaft inside a coil of wire; an AC current would be fed through the coil to magnetise the shaft and changes to its magnetic permeability (and hence the applied stress) would be measured by recording the induced voltage. This offered a stress-based method that was truly non-contact but it came with a number of drawbacks – most noticeably the need to supply a considerable amount of electrical power to keep the AC magnetism going.

"To be clear, all these methods are amazing in their own right," says Bitar. "But if I'm a manufacturer or a race team, I don't really care what's going on under the hood. I want the smallest, lightest, simplest, most reliable and most accurate torque sensor."

> *"The relationship between strain and stress (and hence torque) is not entirely linear"*

The solution came from MagCanica's former chief technical officer Ivan J Garshelis. A highly experienced academic researcher, Garshelis had actually built the magnetic "pliers" that Bitar now uses to demonstrate the magnetoelastic effect while investigating other uses of the phenomenon. It soon became apparent that he had also unintentionally solved the main problems that faced wireless torque measurement. By using a proprietary process to permanently magnetise the shafts, Garshelis had created a method to generate the circular field that didn't require external power.

"The beauty of this approach is that it allows you to extract a torque measurement from a shaft that's largely independent of the rpm of the shaft, and not greatly impacted by temperature," comments Bitar. "All you need to do is place some magnetic field sensors in close and known proximity to the shaft, and now you have a torque signal that can be highly accurate."

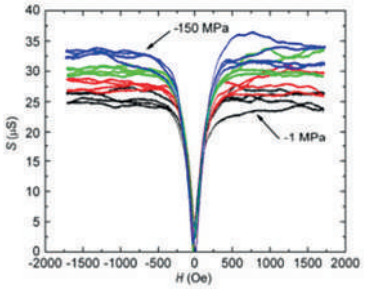
**ABOVE** One of three MTS powered hydraulic torque testing rigs for MGUK shafts, clutch shafts, secondary shafts and driveshafts at MagCanica's base. The thermal testing hardware can be seen installed inside it

**RIGHT** MagCanica's Ultra High Accuracy (UHA) driveshaft torque sensor system enables rule-makers in series – such as IMSA in this case – to regulate power

V10 Formula 1 engine. Ferrari then used the system onboard its Formula 1 car from 2002. Early iterations of the system weren't as accurate as the devices that are now used to police the regulations in IMSA and the WEC, but they had the key advantage over the other technologies available at the time that they were light enough to be used on the car.

"Things have evolved a lot since then," comments Bitar. "At that point, simply getting a repeatable signal in a package that was small enough to be used on the car was a major achievement. People were saying: 'I want to measure torque ... but I don't want to measure it so badly that I'm willing to add a load of weight that will slow the car down'."

Initially, the system was entirely analogue. It provided a faithful measure




**ABOVE** An applied field results in a strain in magnetoelastic materials. The figure is a plot of magnetostriction – key to MagCanica's products – as measured in microstrain (uS) versus applied field measured in Oersted (Oe), while applied stress is varied

of the magnetic field, but it didn't account for hysteresis. Bitar refers back to his earlier demonstration to explain why this is important.

"When I release the force on the handles, the external component of the magnetic field almost disappears. It's very low – easily enough to drop the drill bit – but it doesn't go completely. So, the next time I use it, I'm not starting right from zero," he explains.

The effect is very small, but it's enough to incur a measurable error over time. It also varies depending on the temperature and the stress that is applied to the shaft.

## Signal processing

A new version of the system was launched in 2012, which added a temperature sensor and digital signal processing.

By logging the stress and temperature history of the shaft throughout its lifetime, this system is able to accurately correct for both potential errors. This had got the sensor to the point where it was more than accurate to satisfy ▶

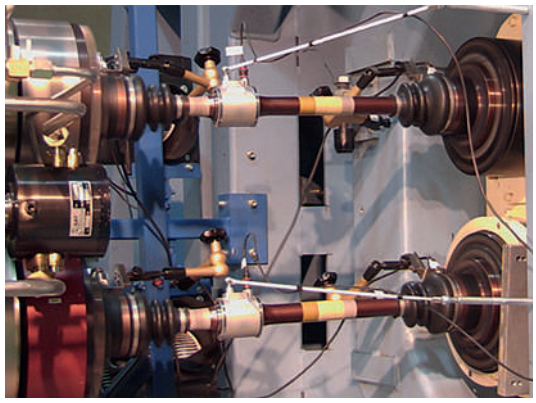
most team requirements, where the emphasis is on repeatability from one test to the next. Regulatory use, however, poses a greater challenge as it requires the system to be extremely accurate in outright terms, comparing one sensor to the next.

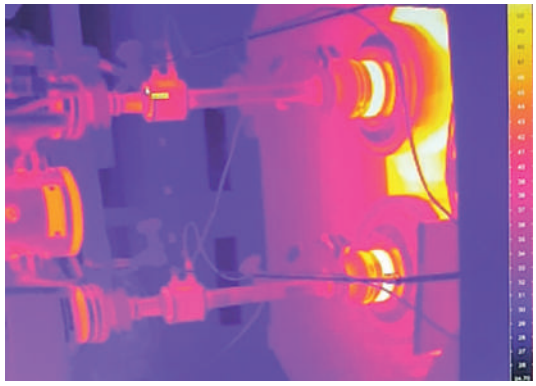
"We ran the system like that for about five years, then we approached the FIA in 2017 and said: 'We've got the accuracy down to the order of 1 or 2 per cent, but we think we can do even better. How good would it need to be for you to use it as a regulatory device?' They came back and said it would need to be less than a quarter of a per cent."

The desire to keep the system small and light enough for the incredibly demanding world of Formula 1 had limited how much additional signal processing technology MagCanica could put onboard. But Bitar and his colleagues spotted that this would be less of an issue in sports car racing, where the packaging constraints aren't quite so tight.

Over the next two years they refined the compensation algorithms – initially offline on the test bench, then with a condensed version of the code that would run in real time on the sensor's own microcontroller.

"That improved compensation method took us down to a quarter of a per cent. And ▶





**LEFT** MagCanica's Ultra High Accurace (UHA) drive-shaft torque sensors – shown below monitored with a thermal camera – have been developed over many years to achieve 'laboratory grade' accuracy while operating in-vehicle, not under controlled laboratory conditions

Charly Lopez/DPPI

**BELOW** The WEC field - all armed with MagCanica torque sensors - lines up in the Spa pitlane

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that's a quarter of a per cent of the actual reading. Sometimes sensor manufacturers talk about accuracy as a percentage of the maximum value the sensor can read, which can be a bit misleading. But we can actually do a quarter of a per cent of reading throughout the temperature range," notes Bitar.

The company also invested heavily in state of the art test benches from MTS and laboratory-grade torque meters from HBM to improve its test and calibration facilities. These are able to simulate scenarios such as the torque spikes that come from kerb strikes and gearshifts.

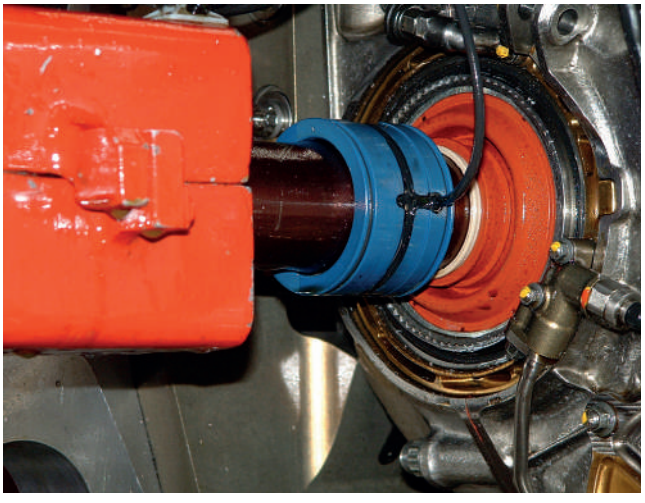
**ABOVE** Engineers at work in the MagCanica laboratory in San Diego, California

**BELOW LEFT** An early generation drive-shaft torque sensor installed into dyno test-cell sensor, tested in 2002

**BELOW RIGHT** The first generation in-vehicle engine output torque sensor, tested in 2000

The most important factor that MagCanica had to demonstrate to the governing bodies and the teams was accuracy. As it started to become apparent that the system could meet the targets laid down by the FIA, the conversation shifted towards reliability, and finally the company's ability to cope with comparatively large volumes.

"Once we'd introduced the second-generation signal conditioning, the main challenge was scaling up," comments Bitar. "We made over a thousand sensors last year, so it's a very different situation to the early days. I'd say we're no longer just an engineering company with a little bit of product, we now very much cover both sides, with manufacturing and product support alongside the continuing development." ▶



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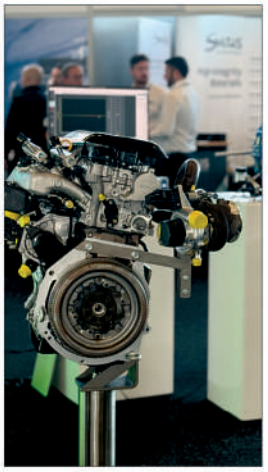

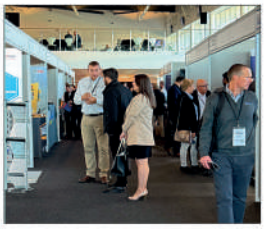

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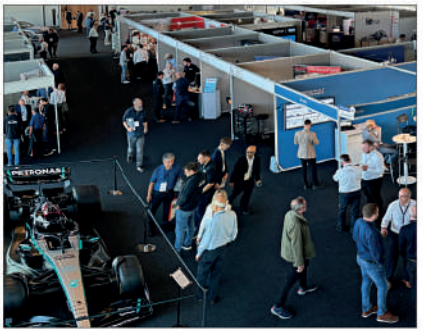


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## Regulatory use

When the LMH class took over as the top category of the World Endurance Championship (WEC) in 2021, it mandated the use of MagCanica's torque sensors for its performance balancing process. By this point, Bitar was already in conversation with IMSA and the LMDh class followed suit when it was introduced in 2023. In 2024, it was extended to the GT3 category in the WEC and the European Le Mans Series (ELMS), followed by the IMSA GTD category at the beginning of this year.

"By the time the system came to GTD, the engineers at IMSA had their own data and their own experience from LMDh, and I think it's fair to say the way they've used it has exceeded everyone's expectations. It's gone well beyond a straightforward balance of performance – they've developed a sophisticated technique for balancing different cars and different powertrains," says Bitar.

Accurate and reliable torque measurement has been a key factor in the level of parity that we see between LMH and LMDh. In GT3 and GTD, it allows manufacturers to define their own unique torque curve to suit the characteristics of their engine, from naturally aspirated V10s to turbocharged straight sixes. Just as crucially, IMSA uses a low-speed curve and a high-speed curve to balance top speeds across designs that vary from front-engined sports saloons to mid-engined supercars. It has also helped to enable the switch to a virtual fuel tank system, which equalises the fuel saving potential across different engine configurations and virtually eliminates the risk of a car physically running out of fuel on the circuit.

All this extra functionality has helped to re-energise sports car racing, leading to some of the healthiest grids in years. Four different manufacturers led the Le Mans 24 Hours at different stages of the race last year, all with a realistic shot at the victory. But it does come with a price. Each sensor costs $9,000. By the time you've got one on each driveshaft, plus a spare set and the various bits to integrate everything into the car we're told the cost comes to around $50,000 per car per season.

Bitar points out that's the cost when the system is purchased directly from MagCanica. Higher figures have been suggested elsewhere and he believes that's partly down to the markups charged by intermediaries. What's more, the cost has been frozen for six years now. Bitar says that MagCanica has found ways to reduce its manufacturing costs, avoiding the need for price increases to keep up with inflation and meaning that the system now represents significantly better value than it did originally. "It's not an

> *"All this extra functionality has helped to re-energise sports car racing"*

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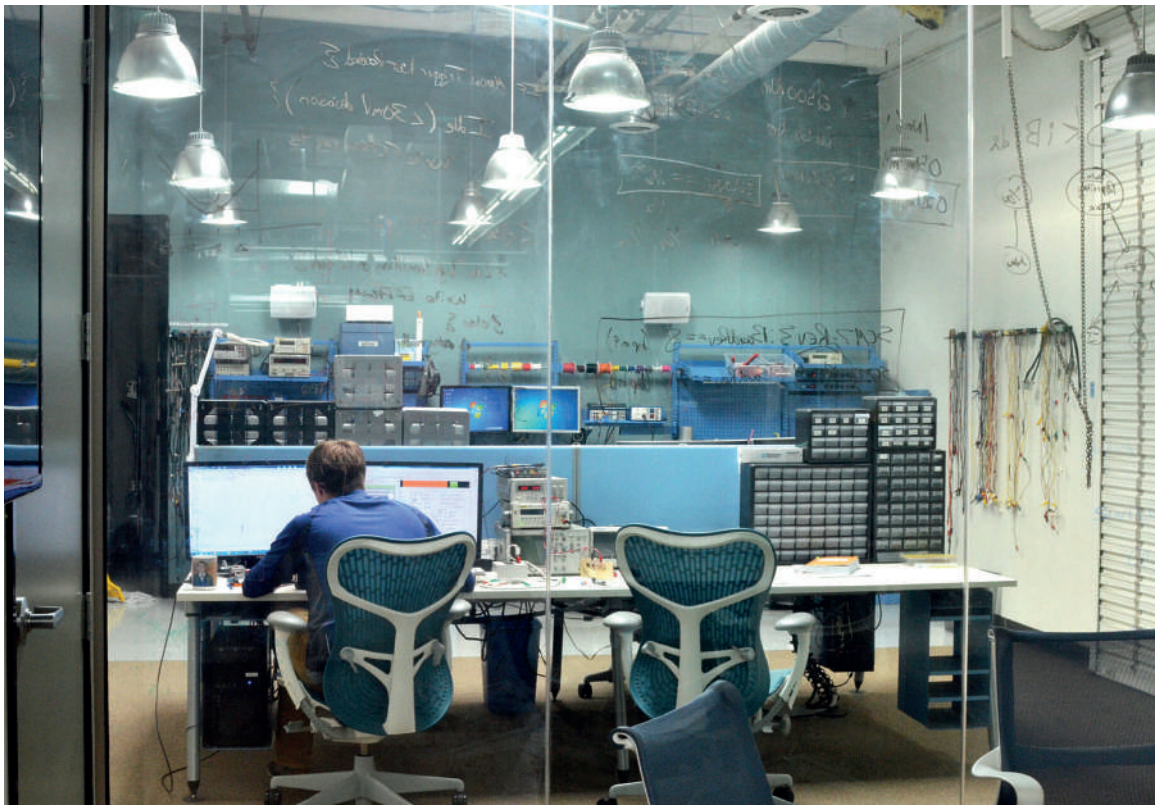
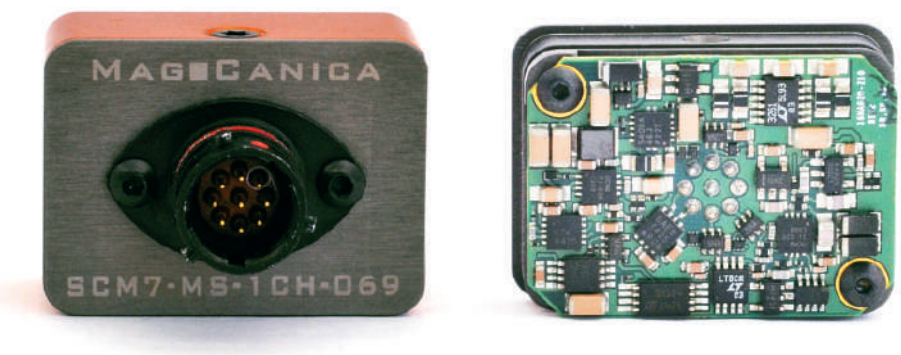
**RIGHT** One of MagCanica's state-of-the-art development areas, as seen through a conference room with its glass whiteboard used for discussions



**BELOW** MagCanica supplies most of the Formula 1 grid plus series including Formula E, WEC Hypercar, IndyCar, NASCAR, IMSA GTP and Cross-Country Rally Car




**LEFT** The SCM7-MS, designed for motorsport, weighs only 23 grams and is rated to an operating temperature of 125°C

insignificant amount, but for what it enables people to do we feel there's a lot of value there," he notes.

Despite the upfront cost of purchasing the sensors, Bitar believes they save money for the series overall: "For governing bodies, torque sensors are a more efficient way to regulate a series, which makes them less reliant on dyno testing. OEMs and teams can potentially run less dyno testing too with the data that they gather on-track from the sensors.

"But I think the biggest benefit is that it enables more sophisticated BoP procedures that can help to allay the potential concerns of new manufacturers entering the series. It's clearly not the only factor, but it hopefully gives the OEMs more confidence to spend money building race cars if they know they can turn up and be competitive without getting into a technological arms race."

In some respects, the stakes have risen for MagCanica. Reliability has always been important, Bitar stresses, but when the company's early systems were being used by Formula 1 teams for monitoring they weren't an integral part of the car. Now, if a sensor fails it could potentially cost someone the race.

"We're certainly very aware of how important the sensors are now, but I think we've risen to that challenge," he comments. "The other thing is that Formula 1 teams are understandably very secretive, so you only tend to find out if something worked or if it didn't work. Whereas now in sportscar racing we're at the track in person on a regular basis so we view the sensor health and diagnostic data in real time – and if there's an issue, we find out about it right away. We've got much more granular feedback about how the system works in a lot of different installations."

So, there you have it. What started out as an idea prompted by a parlour trick has evolved into a system of measurement that's now woven into the regulatory fabric of the biggest sports car championships in the world. It's proof that one little sensor can make a very big difference. RT

**BELOW** Honda Racing Corporation USA powered Alex Palou to victory in May's Indy 500 – based on a steady diet of defeat

Joe Skibinski

# WE LOSE, WE LEARN

That's the key philosophy that grounds Honda Racing Corporation USA's approach to motorsport, as company president David Salters tells **Damien Smith**

"*IT is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood; who strives valiantly; who errs, who comes short again and again, because there is no effort without error and shortcoming; but who does actually strive to do the deeds; who knows great enthusiasms, the great devotions; who spends himself in a worthy cause; who at the best knows in the end the triumph of high achievement, and who at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who neither know victory nor defeat.*"

**Theodore 'Teddy' Roosevelt**

Those stirring words from the 26th President of the United States carry direct meaning for David Salters, the British-born president of Honda Racing Corporation USA, and they underpin everything about the company's involvement in motor racing, from IndyCar to GTP IMSA sports cars to off-road and more.

"Losing or failure is when you learn the most," Salters tells Race Tech from the HRC Indianapolis base on the first morning of practice for the Indy 500. "In racing, you're exposed. You're in the arena. You're out there doing it. And when you're doing stuff, it's going to go wrong. Are you going to win, are you going to lose? Learn from it. Move on. That's why Soichiro Honda entered motor sport in the 1960s in the first place. He said it's 99 per cent failure and 1 per cent success, particularly with development. And you learn the most from your failures."

Not that HRC loses all that often. At the time of our conversation, Honda engines had scooped all five of the IndyCar races run in 2025 – four to Chip Ganassi Racing's reigning champion, Álex Palou, and the Long Beach Grand Prix to Andretti Global's Kyle Kirkwood. Then again, it had been a different story in the WeatherTech IMSA SportsCar Series, where Porsche took a firm grip in the wake of an unbeaten run over Acura and Cadillac. Salters has seen it all, so won't get too excited by the wins or too depressed by the losses, from a perspective drawn from more than 25 years in the motorsport front line that now percolates through every department of HRC.

"The point is, we all know that when something goes wrong it's when you learn

> "Soichiro Honda said motorsport is 99 per cent failure and 1 per cent success"

the most," he says, warming to a theme he espoused so eloquently in a speech at the World Motorsport Symposium held in London in November last year. "It's when you really learn about yourself, learn about what you're doing, what the work is. So actually, the losing or the failure bit is critical, because that's how you're going to learn and improve."

Before HRC, Salters contributed to a fair bit of winning (and losing) in the Formula 1 arena. After foundation years working on Cosworth's CART IndyCar engines in the second half of the 1990s, he switched to what was then Ilmor (now Mercedes-Benz Performance Engines) and rose to be head of F1 engine development from 2003-06 for the V10s and later V8s that ▶

Levitt/LAT Images

of getting a lean, agile group of people to work together to achieve things that when you start out seem unlikely. Humans are pretty impressive. When you have a goal, you tend to achieve it."

Salters also enjoys the binary nature of motorsport. You win – or you lose. "Racing gives a very clear result," he says. "There's no BS, is there? You can make as many excuses as you want, but it's pretty clear what happened. It's sport – in our case a technical team sport. That's why Honda races."

He acknowledges the old 'race on Sunday, sell on Monday' promotional aspect. "But within Honda, it's about developing the people and the technology. That's why you do it, and that's why

> *"We're programmed to win but we learn the most when it's not going that well"*

powered McLaren. Then he served as head of engine development for the Ferrari F1 programme for nine years from 2006, a spell that covered the 2.4-litre V8 era, Kinetic Energy Recovery Systems and the modern-day hybrid turbo V6 powertrains. In 2015 he joined what was then Honda Performance Development (HPD), of which he has been president for the past five years as the business transitioned into HRC US.

Learning from losing is all very well, but as Salters knows every manufacturer must justify its heavy motorsport investment to a board of executives – and that's far easier if you're winning. "Of course, we all do it to win," he says. "We're programmed to win. But I maintain we learn the most when it's not going that well, and then provide you are open-minded and take that on the chin... It's the ultimate growth mindset, isn't it? How do you do stuff better? Of course, you also need to justify your existence. You can't just sit at the back of the pack all the time. But that's the challenge of it, isn't it? You have your highs and your lows. But the losing or failure bit is the critical part of developing as you put yourself out there."

## Power to the people

For Salters, as it was for Soichiro Honda in the beginning, motorsport is centred around what it brings to the people at the heart of the company. "A number just have a culture where it's ingrained," he replies when we ask him why carmakers still go motor racing. "Mr Honda raced himself and he figured out it was a good way to challenge his associates and his employees, to develop people, build a team and then just to fast-track technology. Motorsport has a startup mentality. You've got a group of people working together, with minimum bureaucracy, who have got to get a job done with ridiculous deadlines. So that brings a lot of benefits,

Jake Galstad

**LEFT** David Salters took over the reins of Honda Racing Corporation USA after stints at Cosworth, Ilmor and Ferrari

**RIGHT** Richie Ginther took Honda's first Formula 1 victory at the 1965 Mexican Grand Prix to the delight of company founder Soichiro Honda

**BELOW** Acura MSR – shown racing in January's Rolex 24 at Daytona – has yet to topple the dominance of Porsche in 2025

Mr Honda did it originally."

From the classic days of Honda powering Marlboro McLarens driven by Alain Prost and Ayrton Senna to a string of world titles, the rolling roster of employees is a well-known Honda trope. Engineers would come in from Japan, spend time on the racing programme, then return to road car development with the benefit of all that they had learned. Is that still the way in 2025?

"Yes, to a degree," Salters replies. "People come in and go back out again. As you go through Honda, you can see people that have been chief engineers in the racing programme and are now in various positions of authority. I lovingly refer to them as the F1 mafia! I don't know how that translates... And actually, we have a resident engineer from the F1 programme. We have very strong connections to the F1 programme, including for the new engine in 2026, and that's got stronger now we're a part of HRC. If we need to know something through the network of the chief engineers who've been in F1 you can cover a lot through Honda. It's quite handy, actually."

For a specialist racing department, HRC US has grown into a significant size. Salters estimates a total workforce of 270-280 people. "Our key facility is in Southern California, just north of LA," he says. "Then I'm sat here in Indianapolis where we have some race engineers and strategists and the driver-in-the-loop [simulator]. We do IndyCar and Acura GTP, our two key programmes. We have some areas where we ring-fence the workforce, but people can move between the two, which is interesting. We are also involved with some off-road Baja-type racing where we do powertrain stuff. And we're involved with touring cars."

He also drops a hint of something exciting. "Occasionally we'll go throw ourselves up a big ▶

2025 Getty Images

mountain in Colorado." He's referring, of course, to the Race to the Clouds: the Pikes Peak Mountain Climb. "You'll see some interesting stuff coming out for that shortly. Watch this space..."

So is technology transfer from track to road really a thing? We hear it a lot as a means to justify motor sport, but is it genuine? Salters offers an example. "The traction control system on our GTP car is quite smart," he points out. "It's self-aware, it thinks and it models, and it was developed inside HRC. Within Honda, we have a technical forum once a year which is private and confidential, and people from all over the world from different groups bring a technical subject. Our traction control system was considered very interesting from a road car point of view. Road car people were asking 'How'd you do this, how'd you do that?' So that's an example of direct transfer. And from the F1 people, motors, batteries, combustion stuff, control system stuff – that all feeds in. For my road car colleagues, how we manage risk is interesting. How do we make ourselves speedier but still not mess it up? How do we do our work?"

## All systems go

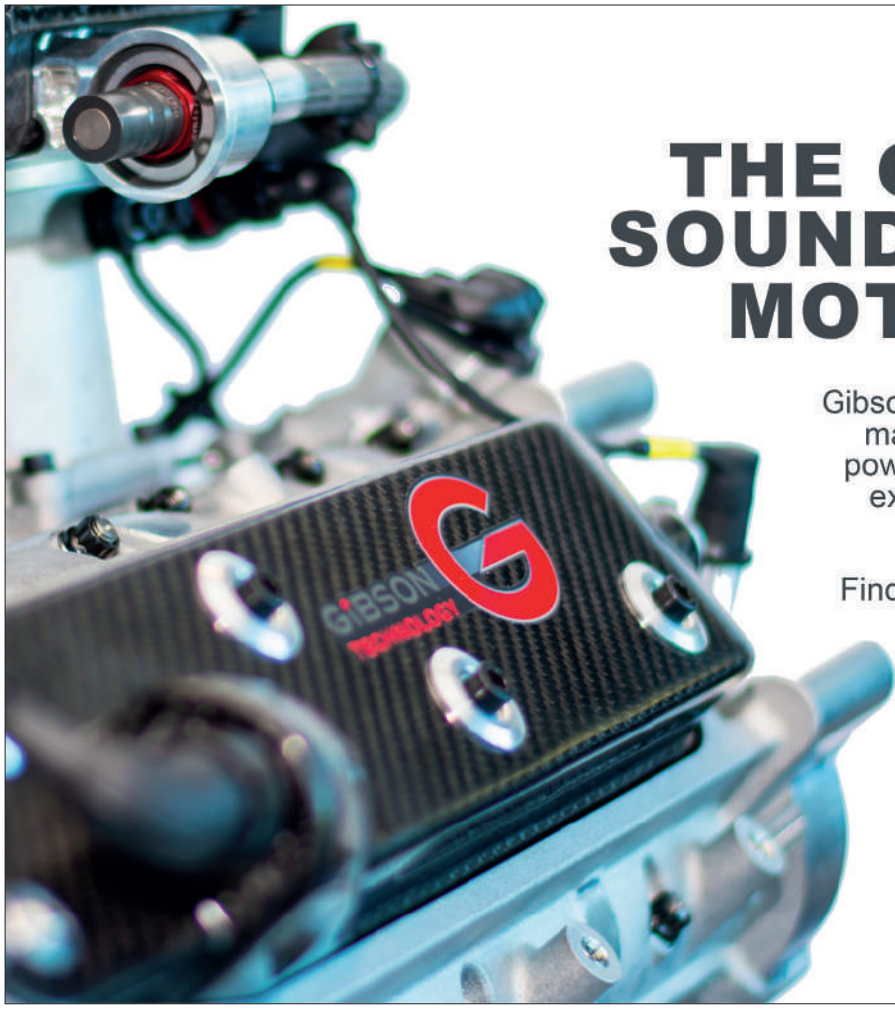
Given that both GTP and IndyCars use spec hybrid systems supplied to all teams, one might wonder how much value they have to Honda. Wouldn't it be better, albeit more expensive, if the manufacturers were free to develop their own systems? Salters' answer explains there's value in the nuance of modern motorsport. "First of all it's just about trying to understand: how am I going to use this tech to try and improve the performance of my race car?" he says. "The goal is we're constantly trying to make a race car go faster, and then we're trying to out-develop our competitors. So in GTP the hardware is standard, but all the systems that control it are written in-house. So, when we harvest and deploy energy, how will it affect the vehicle dynamics, to stabilise the car or make it turn? Also we have to look after the system, so we need to keep it within operating parameters while pushing it as hard as we can. It's in an aggressive environment."

HRC has expanded its involvement in GTP by including its employees in the race engineering aspect of running the Acuras, of stepping beyond simple powertrain supply. "It gives people more opportunities," explains Salters. "We have a lot of smart vehicle dynamicists here who are basically involved with developing race cars, who have now ▶

**ABOVE** HRC US has strong connections to the F1 programme and will play a role in the development of the new powertrain for 2026

**BELOW** Honda Racing Corporation USA encourages its engineers to gain extra experience with race strategy

Levitt/LAT Images

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Geoffrey Miller

**LEFT** Honda engineers at work at this year's Indianapolis 500. David Salters insists HRC US's greatest assets are its people

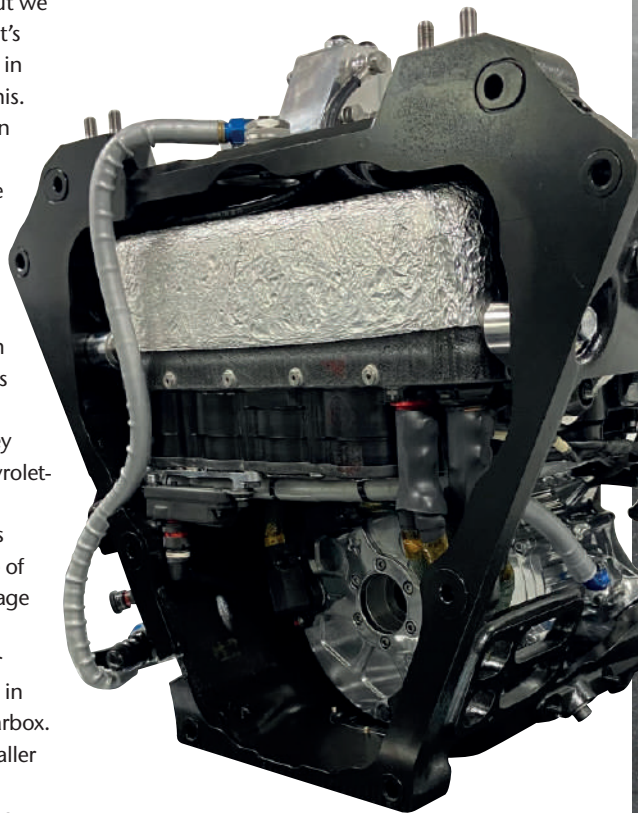
**BELOW LEFT** IndyCar's rival manufacturers collaborated to design and package the hybrid unit

> *"Mainly you want to put together championships, but it's the Indy 500…"*

been involved with performance engineering and strategy. So let's give them some opportunities. It also brings the factory and the track closer. We work with some brilliant race teams and we love that bit, but we also want the challenge of racing a car, because it's just going to make us more aware, more realistic in what goes on. So that's the reason we've done this. It's been hard. After all, the level of competition in endurance racing these days is off the charts. No one's sparing the horses these days, are they? We started off pretty well, put it on the podium a couple of times, went backwards a bit, and now we're getting back on our horse, I think."

The same methodology, to eke the most out of a spec system, is relevant to IndyCar too, although Salters has stopped short of placing race engineers at teams in this arena. But he points out that HRC is also responsible as a supplier to IndyCar for a key aspect of the spec hybrid powertrain, for the Chevrolet-powered teams as well as its own. "We supply IndyCar with the supercapacitor packs, which was not originally planned," he explains. "In the space of nine to 10 months, we made a whole energy storage system, which was a challenge, but a good one. That's what we like. New stuff. The supercapacitor lives in a pretty horrible place, but it's a safe place: in the bell-housing, between the engine and the gearbox. You couldn't think of a hotter, more vibrating, smaller place to put very sensitive electronics."

This project required what Salters describes as a "lovely thing": a collaboration with HRC's great IndyCar rival, Chevy. "GM Ilmor sorted the motor out, so we all worked together," he says. "We're normally trying to kill each other on the race track! But here we all worked together and made a system that's novel and unique. OK, everyone's trying to compete, to beat each other. That's during the match, during the race, during the game. But when you walk away from the field of battle, there is a lot


Honda Racing Corporation

IndyCar

of respect for your counterparts, because we all know what we're all going through. Let's respect each other and look after each other. We achieved something together for the greater good."

As for the future, Salters won't be drawn on what he thinks about the next-generation IndyCar. That's the series' business, not HRC's, he says. But he would welcome more manufacturer competition, if one or two would be willing to plunge in.

## Indy redemption

Finally, as we're speaking ahead of the Indianapolis 500, we must mention the great race. Salters recalls feeling "mentally scarred" by it back in 2017 when Fernando Alonso lost his Honda engine during the closing stages, just as he looked set to fight for victory. "I was almost physically sick, to be honest," Salters recalls. "You could hear the groans of the crowd over the engines. But Takuma [Sato] won. Alonso did a fantastic job, didn't he? He would come to the simulator every day. Like all champions, super-fast, super-smart, also worked really hard."

But there's the big question... what counts for most: an Indy 500 win or the championship? Salters smiles. "The 500 is the Indy 500... I mean, they're all important, you gotta love all your children equally! Mainly you want to put together championships, but it's the Indy 500... It's like trying to win Daytona or Le Mans, isn't it? There's nothing quite like it. It's called the greatest spectacle in racing. If you've been there and seen 350,000 people watching the pure heroics of the drivers, the gladiators that are in these cars... Once you've seen it and felt it and smelled it and touched it, you know."

A couple of weeks later, Salters is among the first to congratulate an ecstatic Palou after the Spaniard breaks his oval duck by winning the biggest race of them all. That's five out of six for the three-time champion this term, and an unbeaten half-dozen for HRC. Losing is learning? Sure. But Teddy Roosevelt's hard-knock lessons can come on another day. RT

James Black

**LEFT & ABOVE** Alex Palou's 2025 Indy 500 triumph came about thanks to the heartbreak of defeats such as the one suffered by Fernando Alonso due to an engine failure at the same event in 2017

# SLICK OPERATION

Michelin is improving the sustainability of its motorsport tyres, revealing its latest breakthrough to be used next year in WEC and IMSA. By **Gary Watkins**

**MICHELIN'S** new range of slicks for the Hypercar and GTP categories look different. But to overplay that would be to miss the point of the tyres to be introduced into the World Endurance Championship and the IMSA SportsCar Championship in 2026. The big development isn't what looks like swirly tread pattern on the Michelin Pilot Sport Endurance tyres but the constituent parts that lay within. The French supplier will hit its target of 50% sustainable materials in its endurance tyres for next season as part of the drive to achieve 100% by 2050 – and that's not just for competition but for the road as well.

The pattern on the tyres, says Michelin Motorsport sportscar operations manager Pierre Alves, is designed "to make the invisible visible". He points out that what the French supplier is calling a "micro velvet" effect – which has already been used on the sidewalls of some of its road tyres – will disappear the moment "the drivers spin the wheels" leaving the pits. "Every time we bring an innovation, the tyres are still black and round," Alves continues. "There are new things inside these tyres, so what better way to show it than to have something that is visible."

Michelin makes great play of the innovations it has made over a history that started in 1889. It produced the first radial tyre for sale in 1946, took a first class victory with the technology at Le Mans as early as 1951 and then a first overall triumph at the French enduro in 1978, one year after it pioneered the use of the radial in Formula 1. Motorsport provided the arena in which it could prove and promote – and fine-tune – its technological advances.

Tyre development in motorsport was traditionally driven by the twin targets of race victories and championship success, but that is no longer the case for Michelin in top-line endurance racing. This is a manufacturer that has an unbeaten sequence of Le Mans victories stretching back to 1998 and that has been the mandated sole supplier since the introduction of the Hypercar and GTP classes on either side of the Atlantic in 2021 and 2023 respectively. It also had a monopoly in LMP1 prior to the arrival of the first wave of Le Mans Hypercar machinery from 2017 and it was awarded the tyre supplier deal for the Daytona Prototype international IMSA division that preceded LMDh from 2019.

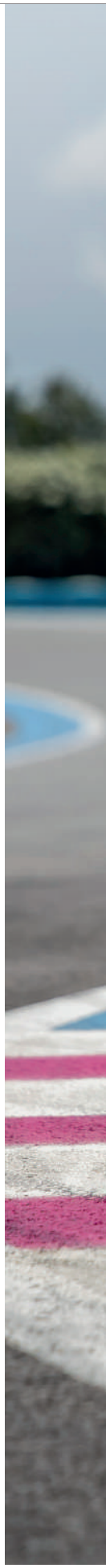
> *"Every time we bring an innovation, the tyres are still black and round"*

Now it chooses to push the envelope differently, epitomised by its #WeRaceForChange marketing tag line. Its monopoly on the provision of tyres for LMH and LMDh has facilitated its drive to drive up the percentage of recyclable and renewable materials in its endurance tyres from the current 30% to 50%.

"We are using motorsport in a different way to 20 years ago," says Michelin Motorsport technical director Philippe Tramond. "If we were in competition with another tyre manufacturer, we would only push for grip and lap time. Introducing new tyres every weekend like it used to be in F1 would mean we would not have the resources to develop sustainable materials." Now competition offers Michelin, adds Alves, the opportunity "to bring something new that we can transfer to market".

The new boundary conditions of its engagement at the top of the sportscar tree has allowed Michelin to hit its 50% target for what it is keen to stress will be mass-produced tyres: it will build 30,000 units a year for use in WEC and IMSA. It has produced technological demonstrators as well as race tyres in low volumes with similar percentages. The rear tyres used in the MotoE World Cup, the FIM's electric motorcycle series, have hit nearly 50 percent biosourced and reclaimed content, ditto those used in two generations of hydrogen fuel-cell technology demonstrators. Tramond reveals that no more than 2000 units per year were produced for MotoE.

Michelin's development of the latest Pilot Sport Endurance range for the WEC also enables it to prove the credentials of sustainable tyres. "What better platform than endurance to demonstrate that sustainable materials work," says Tramond. "With endurance ▶



**BELOW** The swirly tread pattern on the all-new Michelin Pilot Sport Endurance 2026 tyre disappears instantly but its real secrets lie within

All photos: Marc de Mattia/DPPI

comes very demanding conditions. It really is the best platform to demonstrate that sustainability goes with performance."

## What's in the tyres?

The obvious question to ask on that point is whether it would be possible to produce a race tyre out of pure natural rubber rather than incorporating synthetic alternatives, which have traditionally been produced from fossil fuels. The answer is yes and no.

"We could do a tyre with only natural rubber, a 100% renewable material. Big progress? No! First I don't think we would have the natural rubber available for that," says Tramond, who stresses that sustainability also means a commitment to protecting the environment and the people involved in the cultivation of rubber trees. "Secondly the performance would be poor. Very poor."

So the question is how to replace the elements of the tyre made from non-renewable materials – and that includes silica, which Michelin first used in road tyres in 1992 to reduce rolling resistance. "For us, silica is not renewable because it takes more than the length of a human life to be renewed," says Cyrille Roget, Groupe Michelin's technical and scientific communications director. "So we have to replace silica with something that is renewable on a human scale."

Michelin has chosen rice husks as an alternative through pyrolysis. "Rice skin is a waste product that is available in large quantities – if you can imagine all the rice that is eaten in the world," says Roget.

The use of rice husks shows how widely Michelin cast the net in its quest for sustainability in the development of the new WEC/IMSA tyres. It tested 11 new materials defined as renewable or recycled and it has ended up retaining seven. "We also tested 14 technical bricks, meaning change in the structure or architecture of the tyre," says Tramond. "In the end only five were successful. It shows we were really in a research and development process."

Michelin hasn't gone into detail about all the materials it will be using – and indeed it can't because the final decision about the spec of the tyres has yet to be made. But it has made much of its use of recovered carbon black, an integral part of all tyres used to enhance strength and durability, which also protects against damage from ultra-violet light. It is working with a Swedish company called Enviro Systems in this area.

"They have developed pyrolysis technology for the tyre at end of life, then you end up on the one side with recovered carbon black," explains Roget. "On the other side you have three types of pyrolysis oil, light, medium and heavy: all those can use to create new resins to replace petrol. We are able to use everything that is coming out of the pyrolysis of tyre at end of life."

Other sources of biosourced replacements for fossil oils include sunflower oil plus lemon and orange skin, while yoghurt pots are mentioned as a source of styrene. But increasing the percentage of renewables and recyclables wasn't as simple as substituting a sustainable material for a non-sustainable one, Tramond says. "Because the new raw materials have different properties, we couldn't just swap one ingredient for another in the same proportions," he explains. "We had to completely redesign our recipes. A major difficulty was reformulating all our rubber compounds and revising our mixing techniques." ▶

**ABOVE** A Michelin engineer takes temperature readings back in the Paul Ricard garage after a run

**BELOW** Michelin's 2026 tyres on Toyota's GR010 Hybrid – carrying a livery inspired by the TS020 from 1998 and 1999 – at the Paul Ricard test

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## And what goes out?

The new Michelin endurance slicks will be fully recyclable. "Working with our partner Enviro we will be able to recycle the tyres from endurance racing, starting in Europe in 2026," says Roget. "We have been able to develop the logistics and verify the feasibility of incorporating race tyres into the normal feedstock of Enviro's recovered carbon black." That means it will not be "race tyre to race tyre"; rather Michelin's race programme will provide raw materials for its manufacturing plants. It is an important step, he insists, in "reducing motorsport's environmental footprint".

The target for Michelin wasn't to produce faster tyres. That, Tramond suggests, "would be pointless because there is a system of Balance of Performance". He is actually talking there about ultimate one-lap performance, because he and his team went into the development of the new range with two key aims that come under the heading of performance: to improve tyre warm-up and longevity.

Warm-up remains a talking point in the WEC ever since the ban on tyre warmers or heaters at the start of 2023. The debate is much muted since the move came in for heavy criticism by drivers and manufacturers alike after a series of out-lap incidents in the opening half of the season. It led to a temporary – for one race only – lifting of the ban for Le Mans in what was its centenary year.

Alves describes warm-up as the "weakest point of the current range". Michelin is predicting a Hypercar will gain on average between three and five seconds on an out-lap depending on compound, measured from the start of sector two straight out of the pits to the start of that sector on the first flying lap post-pitstop, on a regular circuit.

An improvement was targeted without having an adverse effect on the consistency and longevity of the tyre. Getting more heat into the tyre quickly improves warm-up but, says Alves, "heat is the enemy of the tyre" when it comes to longevity. A compromise was required. ▶

**ABOVE** Michelin's mechanics with a used set of the Michelin Pilot Sport Endurance 2026 slicks at the Paul Ricard test

**BELOW** Pierre Alves, Philippe Tramond and Cyrille Roget show off their latest product

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Michelin is confident that it has achieved this and it is already talking about a decrease in the tyre allocation for each WEC race and greater multiples of stints at Le Mans. For the regular six-hour events it currently stands at four and a half sets or 18 tyres, while triples and even quadruples are possible at Le Mans in the Hypercar era.

"We have to understand how this new range will perform," says Tramond. "Then the aim will be to reduce the number of tyres each car uses over an event. We need to give the teams time to understand the tyres and how to exploit them." He suggests a reduction could come in 2027, year two of the new range, with the necessary regulatory approval, of course. "To innovate without hurting an ecosystem that works" is Michelin's aim, he insists. As for Le Mans, Alves asks: "Why not push the limit of the tyre further in Le Mans in terms of multiple stints?"

That understanding is also likely to result in a lowering of lap times. Alves points out Hypercar/GTP grids have gone quicker by a second a lap a season and he believes that getting the most out of the tyre has played a crucial part in that.

As with the current range there will be three specifications of slick: two are brought to each WEC race and all three to Le Mans, while in IMSA it is one spec per race except for the season-opening Daytona 24 Hours. They are to be known as soft, medium and hard – differentiated by white, yellow and red markings on the sidewalls – like their predecessors. They were originally called the 'soft hot', 'medium' and 'medium hot' to reflect the temperature ranges in which they were designed to be operated, though a switch was made for 2024 to try to make the options more understandable to the wider world.

It is important for Michelin to offer different choices to the manufacturers and teams. "Why do we need to have three compounds? Because the cars are different," explains Alves. "The cars work differently: some cars put more energy in the rear tyres, some more on the front. Some are two-wheel drive, some are four-wheel

**ABOVE** Michelin engineers check the data on the new slicks during the Paul Ricard test in the Alpine garage

**BELOW** The Alpine A424 Hypercar puts the 2026 Michelin Pilot Sport Endurance tyre through its paces at Paul Ricard

drive, some with a hybrid and some without. We need tyres that are right for everyone in every condition, and we need a good overlap or crossover."

## The timeline

Development of the new set of WEC/IMSA specifications started while that of its predecessor was finishing. That was undertaken almost entirely in the virtual realm save for the final validation – for a simple reason. There was no Hypercar machinery available except for the final stages of the process in the lead-up to the first wave of LMH machinery coming on stream in the WEC in 2021.

Simulation has remained an important tool in the development of the 2026 tyres, however. It is something Tramond describes as "one of our strengths". It remains "the first step", continues Alves, "and if everything is working as it should be, we'll build it and run it on track."

Track running of next year's slicks started as long ago as early 2023. The testing programme has continued until now on both sides of the Atlantic: all manufacturers building LMH or LMHd machinery are invited to each test so it's up to them whether or not they attend.

**LEFT** Michelin is aiming for 100 percent sustainable materials in its endurance tyres by 2050

> *"Heat is the enemy of the tyre when it comes to longevity"*

Michelin picks the tracks on which it tests new tyres carefully. Paul Ricard, the Algarve circuit near Portimao and Spa are its favoured locations in Europe; Sebring, Watkins Glen and Road Atlanta in North America. Ricard, for example, provides a long straight, the Mistral, in excess of one kilometre in length and the Signes right-hander at its end is a corner that provides sustained loading on the tyres.

"The maximum speed at the end of the Mistral is 320kmh, which is nearly up there with the 340kmh achieved on the Hunaudieres [Mulsanne Straight] at Le Mans," explains Alves. "The tyre load in Signes is 1.5 tonnes for a sustained period – not unlike the compression at the bottom of Eau Rouge at Spa."

The final test in Europe came at Paul Ricard in mid-May – Michelin was working on the medium at the venue in the south of France – while the last run in North America is set for Watkins Glen after June's six-hour fixture at the circuit in upstate New York. After that the final decisions will be made. The structure of the tyres is already set, but Tramond explains what goes into the compounds – including the materials used – will be "made in July when everyone is on holiday!" It also could be affected by the make-up of the 2026 WEC calendar due to be unveiled during Le Mans week, he points out.

That will be followed by what he describes as an "industrialisation phase", including making the necessary tooling, before a September start of production that "will ramp up slowly". It will be accompanied by development of virtual models of the three slicks. These will be made available to the teams so they can start testing the finished articles in their simulators before they put their machinery on the real thing. Teams will be able to begin running on the 2026 tyres in mid-November. The release of the new range to those competing in the WEC will coincide with the traditional IMSA sanction test at Daytona.

The original plan was to introduce the new tyres for the current 2025 season yet the introduction had to be moved back for two reasons: firstly poor weather during a test at Portimao early last year delayed development, then a company earmarked for the supply of some of the sustainable materials couldn't meet the volumes demanded. Tramond suggests this was a blessing in disguise, the extra time allowing Michelin's tyre designers and engineers "to be a bit more creative".

The new tyre range is for the slick only – at the moment. A wet-weather Michelin with 50% sustainable materials is well on the road to being ready too, says Alves, even though encountering the right conditions in which to test it is a matter of luck. "Every time we have a private test, we always have some wet tyres in the truck so if we get to chance to test them, we do," he explains. But it also has a stock of unused wets of the current generation. "We are sustainability sensitive, so we will use these tyres before introducing the new wet."

## What's next

Michelin has the Hypercar supply deal until the end of the 2029 season, the current end date of the existing LMH/LMDh ruleset. The new tyre range will be in use for a minimum of three years and Tramond reveals that what happens next is already under discussion. He stresses, however, that there are "a lot of ifs" at a time when it appears highly likely that the rules will be extended yet further, quite possibly to the end of 2032.

"Internally we are already thinking about what we could do to push the level even higher," he says of the percentage of recyclable and renewable materials in the WEC/IMSA tyres. That will be the next step on the road to a 100% sustainable tyre in 2050. "We have a road map where we know how to replace most of the [non-sustainable] materials," says Tramond. "We know how to get to 97-98%: there are a few materials, mostly additives, for which we don't have a substitute."

But Tramond is confident that, aided by the work it is doing in sportscar racing, Michelin can close the circle. RT

Fabrizio Boldoni/DPPI

# GEARING UP FOR LE MANS

Transmission specialist SADEV already supplies Peugeot's 9X8 Hypercar. Now it is introducing a new product for the GT3 category, as **Chris Pickering** discovers

**FROM** Trophy Trucks to Formula E, French transmission specialist SADEV is involved in almost every facet of motorsport. But for one week in the middle of June, much of the attention will turn to sports car racing. Specifically, the LMH category at Le Mans, where SADEV has worked with Peugeot to co-develop the gearbox and the front reducer used on the 9X8.

"It's a very exciting project to be working on. In this category, our transmissions participate in some of the biggest races in the world, so what we design and produce has to be perfect," comments SADEV's design office manager, Fabien Poisson.

Part of the appeal, from an engineer's perspective, is that the LMH regulations are relatively open where the transmission is concerned, and SADEV is only dealing with a single manufacturer on this project, so it is a truly bespoke design, unfettered by many of the constraints that apply in other cases.

LMH gearbox casings must be made from aluminium or magnesium, while the gears must be steel. There's a minimum weight of 75kg for the complete assembly, and its centre of gravity must be at least 150mm above the reference plane (a horizontal plane defined by the lowest point of the bodywork and the upper surface of the skid block). No more than seven forward speeds are permitted. There must be a mechanical reverse gear and dual clutch transmissions are outlawed, as are F1-style seamless gearboxes and CVTs. And that's about it. The whole gearbox section takes up just over half a page in the technical regulations, leaving plenty of freedom for the engineers to get to work.

> *"SADEV is only dealing with a single LMH manufacturer so it is a truly bespoke design"*

"The layout is very important, not only for the gearbox itself, but for the whole of the back of the car," Poisson points out. "The shape of the gearbox can impact the aerodynamic features at the rear. It's also a structural part of the chassis, with the suspension loads going directly into the casing.

"These chassis loads are the most challenging part of the structural design of a stressed gearbox. We have some

**ABOVE** SADEV's work with Peugeot on the 9X8 is so integral, the shape of the gearbox impacts the aerodynamic features at the rear

powerful simulation tools to analyse this and it's something that we are now very used to doing. The most challenging aspect of the start of the project is finding the data on the loads that will be coming in from the track."

Like the other LMH and LMDh manufacturers, Peugeot has opted for a 7-speed configuration. All LMH hybrid systems use a single motor generator unit (MGU-K) driving the front wheels, in contrast to the spec rear-mounted hybrid system in LMDh. The rules specify that the front transmission – known as the reducer – must use a single speed. This unit also faces the challenge that it has to transmit significant torque in both directions.

"We've learnt a lot in Formula E, which also runs a front reducer," comments Poisson. "The behaviour of the components is not necessarily the same when you load them in the other direction. That applies to the gears, but also to the bearings and even the oil flow inside the casing."

Packaging is no less of a challenge at the front of the car. The MGU-K sits level with the pedal box, occupying the space that would be the passenger footwell, while the reducer sits just ahead, running down the centreline of the car. There are structural components in all directions, not to mention the driver's feet to accommodate.

## GT3 plans

SADEV is also working on a high-torque two-wheel drive gearbox for GT3 applications. This draws on the same expertise as the LMH gearbox, but the philosophy behind the two is quite different. In GT3, the aim is to suit the demands of individual customers by customising a selection of standard features, rather than developing a completely clean sheet design. The range of potential layouts varies hugely, from front-engined cars with front-mounted gearboxes to transverse or longitudinal mid-engined configurations and front-engined cars with rear-mounted transaxles.

"The casing, of course, will be different, but there isn't that much difference internally between a front-engined and rear-engined gearbox in GT3," notes Poisson. "One of the big differences to LMH is that the gearbox is not a structural part of the chassis in GT3."

The GT3 category also covers a very broad range of engine architectures from six-cylinder turbos to screaming naturally aspirated V10s, each with their ▶

Julien Delfosse/DPPI

own torque characteristics. A pair of gears in constant mesh can be used to adjust the input speed up or down to suit the speed and torque range of the main gear cluster. Different clusters are still required to fine tune the individual gear ratios – both to suit the car and to tailor its performance to specific tracks – but the overall spread of ratios and the core design can be shared.

"Generally, if you have a high-revving engine you have less torque, which means that the gears go through more rotations, but at a lower load. And if you have a low-revving, high torque engine, it's the other way around. We have good modelling tools that allow us to determine the sizing of the components to deal with each of those scenarios," comments Poisson. "It's also possible that a higher revving engine might require more gearshifts over its lifetime, so you need to look at the design of the dogs and the selector forks. We need to make sure that all the current GT3 engines will work with the gearbox, and we also need to extrapolate that to make sure that it should be able to cover future applications."

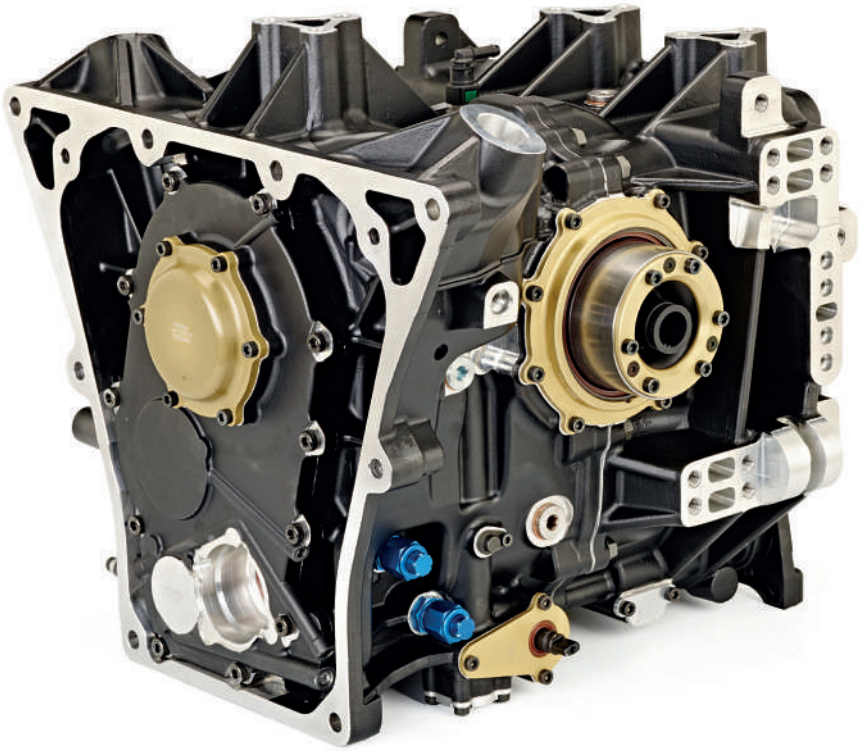
Fundamentals, such as the internal layout of the cluster, the shaft spacing and the lubrication concept are carried over from one variant to the next. However, the external shape and orientation can be tailored to suit the application. This is a similar approach to the firm's Rally 2 gearboxes, which are all based on the same transverse front-wheel drive layout, which is adapted to suit the packaging requirements of each manufacturer.

**ABOVE** SADEV is working on a high-torque two-wheel drive gearbox for the GT3 category of the WEC

**BELOW** SADEV tailors solutions for its clients, such as this transmission co-designed and manufactured for Renault's RS01 one-make sports racer, which is eligible for GT3

## Electric racing

SADEV's broad range of experience has led to an increasing amount of technology transfer between different applications. While the components don't ▶



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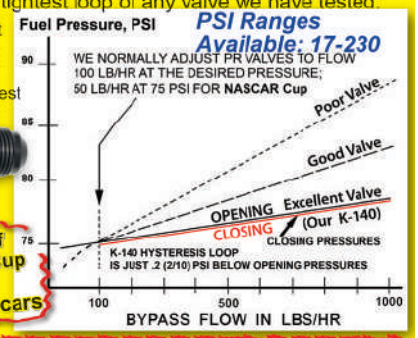


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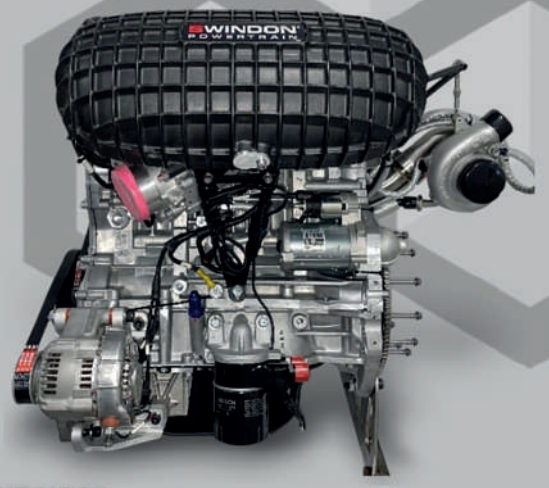


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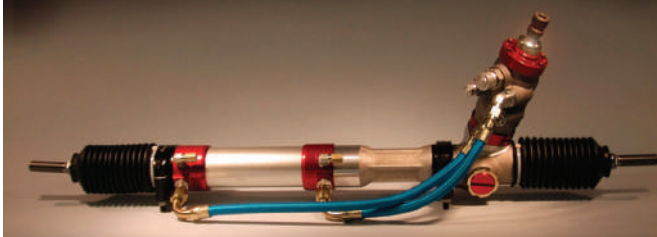

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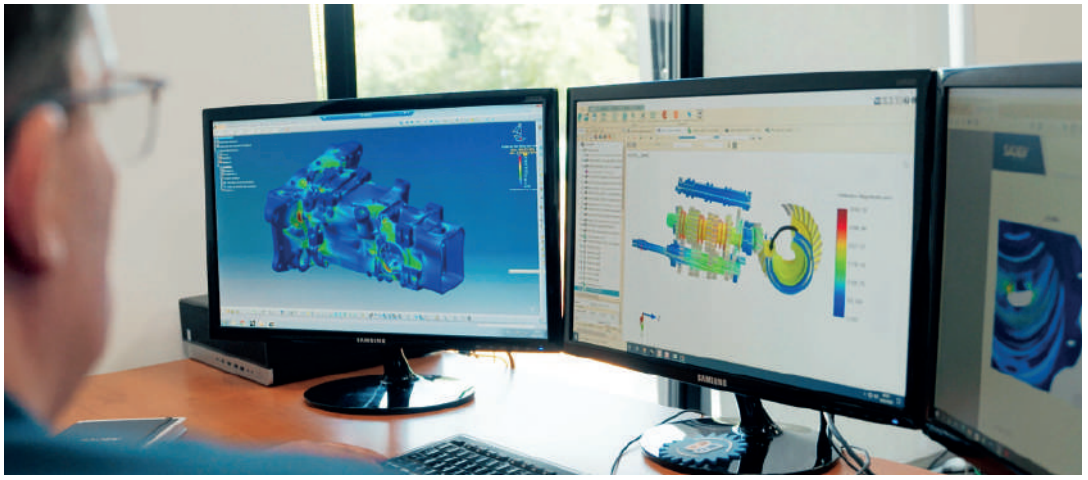
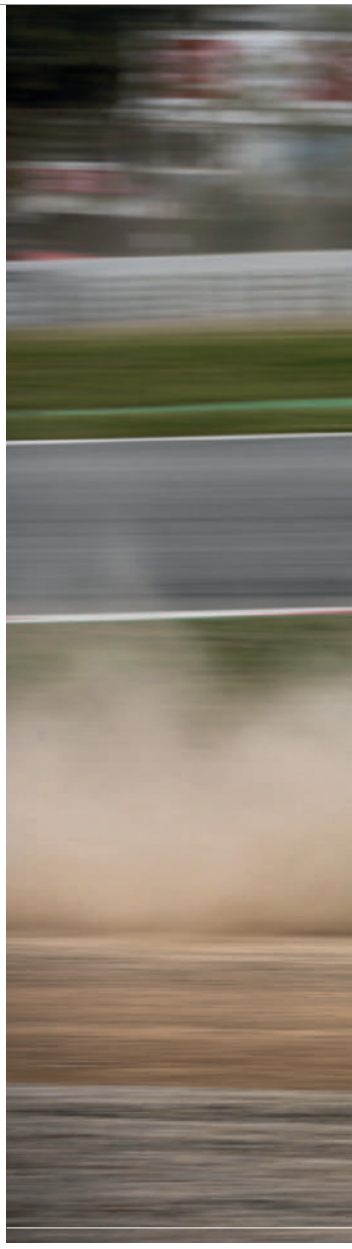
tend to be transferable, it's common for design concepts and development tools to migrate from one application to another – even at opposite ends of the spectrum.

"We do see a lot of technology transfer," comments Poisson. "Last year, for instance, we launched new front and rear differentials for rally raid, and those drew directly from our experience in Formula E. This is one of the reasons why we feel it's important to be involved in so many different categories. They all bring something new, and often that includes concepts that can be used in other applications."

These disparate applications are taking SADEV into new territory. The firm's involvement in electric motorsport extends beyond Formula E into areas such as the RX2e rallycross category and the FC1-X electric rallycross car built by Olsbergs, which features four motors and a 3-speed paddleshift system on the rear (plus a single-speed unit at the front).

"Electric transmissions are very different from ICE in concept, because you have fewer ratios or just a single speed reducer, but you have huge amounts





**ABOVE LEFT** SADEV engineers at work on calculation and simulation with MSCOne Suite (Romax, Apex, Nastran)

**LEFT** SADEV carries out the entire gearbox manufacturing process at its base in the Vendée region of Western France. Here the team prepares parts for assembly

**BELOW** The Nitro Rallycross FC1-X has so much near-instantaneous power (over 1,000hp) the limit is never the motors but the tyres

Jordi Rierola

> *"The FC1-X power is virtually instantaneous, unlike the torque curve on an ICE engine"*

of torque from zero rpm and the motors can rev to 25,000 or 30,000rpm," notes Poisson. "The FC1-X was really something special. There is so much power there [well over 1,000hp] that the limit is never the motors but the tyres. It's virtually instantaneous too, unlike the torque curve on an ICE engine."

NVH is rarely a consideration in motorsport applications, but with electric cars being so much quieter than their combustion-powered equivalents, SADEV has begun to think more about noise levels in both the gearbox and the differential.

"Gearbox noise is not a problem as such, but it is generating new questions," says Poisson. "Sometimes people are asking: 'What is the knocking noise? I've not heard it before...' Yet it's actually the normal operation of the LSD that they just can't hear over the sound of a combustion engine. The very high shaft speeds also give us some new challenges in terms of vibration, as well as differences in the design of the bearings, the shafts, the seals and the gears."

Efficiency is also a particularly important topic in electric racing. In Formula E, for instance, the maximum power is limited by the output of the (spec) battery, but from there on outwards, the teams are free to minimise parasitic losses, and maximise how much of that power actually reaches the wheels.

A similar principle applies to LMH and LM GT3, albeit the other way around. Here, the driveshaft torque sensors limit the torque (and hence the power) available at the wheels. However, maximising drivetrain efficiency will reduce the amount of work that the powertrain must do to meet that target, and hence the amount of energy that will be consumed. It's another example of how the shifting requirements in powertrain technology are placing new demands on the transmission.

For SADEV – now in its 51st year – this is the latest step in a continual process of evolution. Powertrains come and go. Regulations change. But there will always be a requirement for transmission systems that can carry the power to the wheels. RT

# LIFTING THE LEVEL

New techniques are speeding up NASCAR pit stops but are they also increasing the risk of mistakes? **Andrew Charman** investigates

**WHEN** veteran NASCAR Cup driver Denny Hamlin took a second successive victory of the season at Darlington in April, one of his pit crew found himself being interviewed by as many media as his driver.

A new technique being employed by Joël-Alexandre Bouagnon and some of his fellow jack men on pit road this season is shaving vital tenths of seconds from tyre changes in the Cup Series – in Hamlin's case the Darlington stop with three laps to go vaulted him from second place to the race lead. But the increased focus on reducing pit stop time is also being pointed to by some as a possible contributor to a renewed spate of loose wheels in the series.

One of the few direct comparisons between NASCAR and Formula 1 is that both series use external jacks, operated by a pit crew member, to lift a car and change tyres. Back in 2017 onboard jacking was reportedly under consideration by NASCAR during the development phase of the current Gen-7 car that was introduced in 2022. Yet at a time when the pit stops were undergoing a major change with the Gen-7 car employing 18-inch wheels secured by a single nut rather than the 15-inch wheels with five nuts previously employed, NASCAR opted not to go the extra step with the jack. The reasoning was perhaps as much about the mechanics of lifting a 3.4-tonne race car as retaining a part of the sport's heritage.

> *"A new technique is shaving vital tenths of seconds from NASCAR tyre changes"*

With such weight to lift, the jacks employed in NASCAR are effectively a trolley jack, albeit a specialist race version. A single pump when the jack is put under the car's side lifts it far enough to remove and replace the tyres, after which it is dropped and the jack carried round to the other side of the car to repeat the technique.

Unlike the guns now used by teams to undo the single wheelnuts, the jacks are not specified by NASCAR; the leading teams build their own while others buy them off the shelf from ▶

**RIGHT** Sprint race: Jack man Joël-Alexandre Bouagnon runs around Denny Hamlin's car, overtaking the tyre changer, before victory at Martinsville in March

John K Harrelson/Toyota

specialists. They average around 30lb, a weight the jack man has to carry as he runs round the front of the car. As such it's no surprise that all pit crew members are regarded as athletes and NASCAR teams routinely recruit American football players reaching the end of their career.

It was the technique used by Bouagnon, himself a former Chicago Bears running back, that excited observers at Darlington. Straight after dropping the left side of the car, he grabbed the jack in his left hand then, as he ran around the front of the car, he swung it behind his back, crossing his arms to catch the jack in his right hand. This process rotated the handle to set for lifting rather than dropping... then Bouagnon slid it under the right side of the car just as the tyre changers arrived in front of their respective wheels.

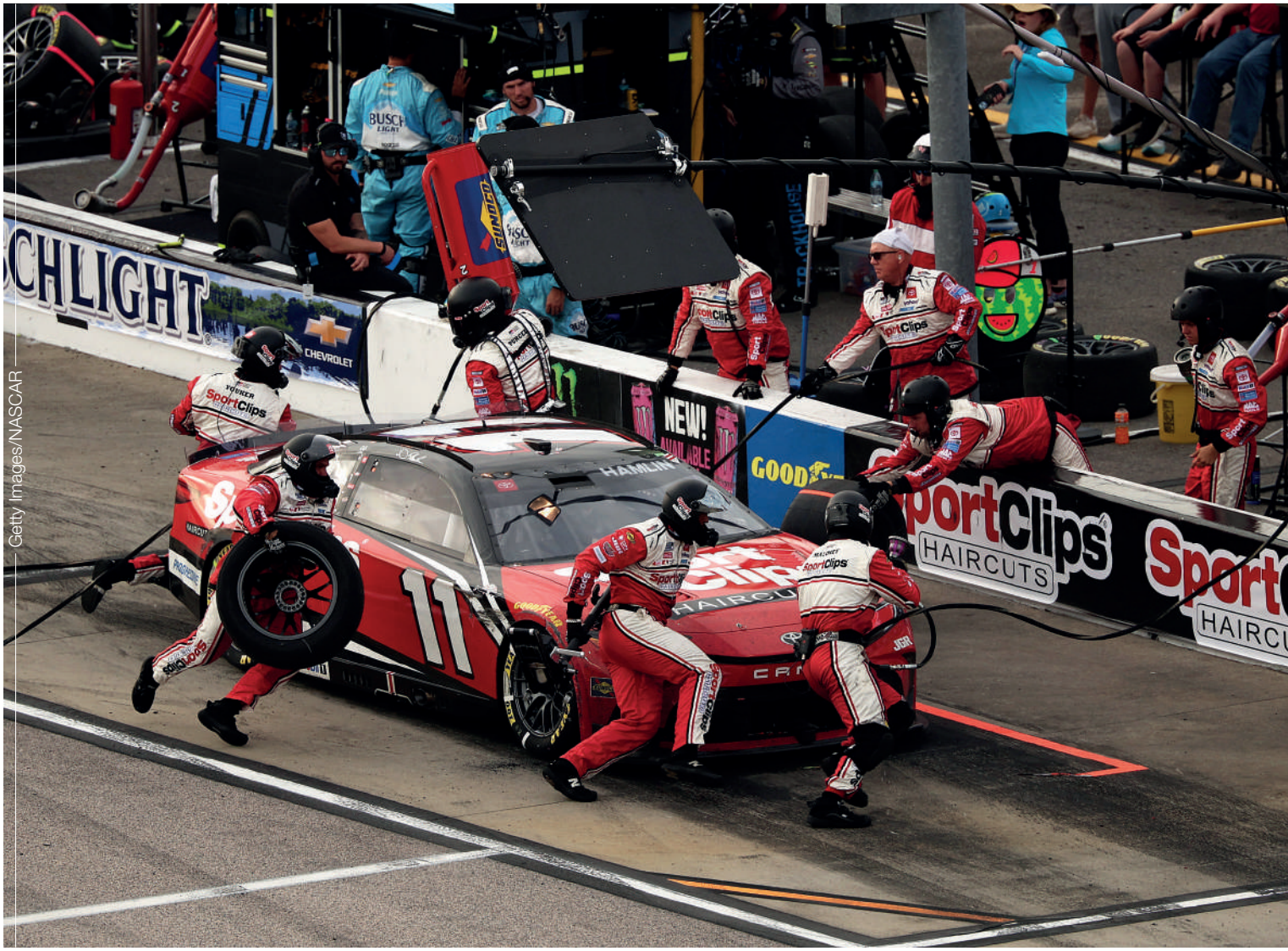
Traditionally in NASCAR pit stops the front tyre changer arrives at the left-side wheel first; he has to hold back to allow the jack man to pass in front of him before dropping to change the wheel. But the new technique allows the jack man to arrive on the left side before the tyre changer, who can drop straight into place to attack the wheelnut.

Boaugnon told TV broadcaster Fox Sports that the technique had taken most of the off-season to learn. Speaking on Denny Hamlin's Actions Detrimental ▶

Rusty Jarrett/Toyota

**ABOVE** Winning habit: Bouagnon's technique helped secure a second successive win for the Joe Gibbs Toyota at Darlington in April

**BELOW** Catch it: Jack man Joël-Alexandre Bouagnon already has the jack in his right hand as he runs around the front of Denny Hamlin's car



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podcast, motorsport writer and IMSA pit crew member Bozi Tatarevic pointed out that a similar technique had been tried by Hendrick Motorsports in the 2024 season – but not as effectively as what was being used this year, primarily by the teams of Joe Gibbs Racing that Hamlin drives for and the 23XI squad he part owns. Hamlin's no 11 Gibbs Toyota team rates second in pitstop time in the 2025 season, beaten only by the 23XI crew of Bubba Wallace.

## Fast and loose

Some observers have suggested, however, that cutting pit stop times could be a contributing factor to rising incidences of loose wheels being seen this year. When the Gen-7 car was first introduced there were several such occurrences, as teams became accustomed to the manner in which the single wheelnut aligns with the pin that pops out of the axle to secure it. According to former championship winning crew chief Todd Gordon, speaking on NASCAR's post-race broadcast following the Martinsville

> *"Cutting pit stop times could be contributing to rising incidences of loose wheels"*

event, the pin only pops into place with the nut around 1/16th of an inch (1.6mm) from being tight, leaving very little margin for error. Gordon believes this is an area that could be addressed by the governing body to cut loose wheel incidents.

Concerned at the prospect of cars losing wheels at speed, NASCAR mandated major penalties for such occurrences. Initially these saw a car's crew chief and two pit crew suspended for four races but from 2023 this was eased back. Now a car that loses a wheel on the track is held on the pit road for two laps, effectively ruining its race, while two crew members earn a two-race suspension. Which members are not specified but typically they

Lesley Ann Miller/Toyota

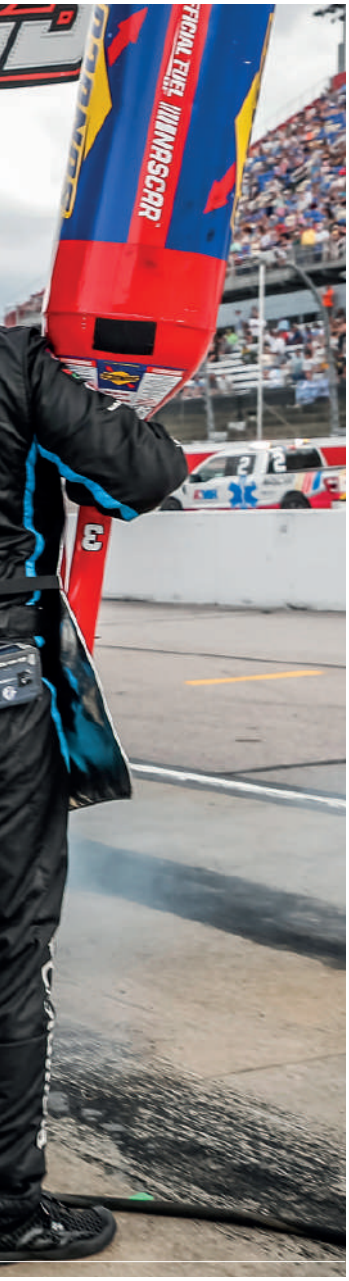
are the tyre changer and jack man.

In successive years the incidences of loose wheels have been generally declining but there has been a spate in 2025 and the pit crew are increasingly in the spotlight. Part of NASCAR's focus on both safety and costs has been a reduction in the number of crew who go 'over the wall' during a pit stop. It is now down to five – and as a result they each now have multiple responsibilities.

When there were six crew over the wall the jack man's only role was lifting and dropping the car so they could watch the tyre changes and spot any issues. Now, however, they have an extra role. On the right side, immediately after raising the car, they hang the new front wheel that has been carried over by another crew member then drop the jack. On the left side they do the same for the rear tyre before dropping the car – long regarded as the signal to the driver to leave.

Rusty Jarrett/Toyota

**RIGHT** Jacked up: The influence of the jack man, here on Tyler Reddick's 23XI Racing Toyota, has increased in recent races




**LEFT** Whole nut: The new single-nut 18-inch Cup wheels have brought their own challenges to pit crews

Tatarevic, a tyre changer in IMSA, told the Actions Detrimental podcast that the jack man now acts on sound rather than vision as a signal to drop the car. Looking at the wheels would take around three tenths of a second which, with the levels that are now routine in today's Cup pit stops, could cost the team five or more places leaving pit road.

Former Cup championship-winning crew chief Steve Letarte agrees. "If you take 11 seconds on a pit stop the wheel won't fall off," he stated on NASCAR's post Martinsville coverage. He added that such incidences would not happen with more crew members over the wall, a view he accepted is unpopular with both NASCAR and the teams.

"(With six crew) the stops would not get a whole lot faster and people would be watching their job, not jack to tyre, tyre to jack," said Letarte. "The current orchestration doesn't allow a pit crew member to focus on one thing."

Such a scenario is not likely to happen any time soon, and unless NASCAR intervenes with further regulation, the jack man technique will no doubt be more widely adopted as just one of the ways teams use to try to shave essential time from their pit stops.

Another innovation tried this season has been in fuel-only stops where a crew member holds an iPad in front of the windscreen, displaying a panel which shrinks and then turns the entire screen green, the signal for the driver to accelerate away. Again the onus is on the pit crew to complete everything they need to do by the time the countdown ends – the pressure is on... RT

Ford

# THE END OF THE DINOSAURS

What caused the death of the dinosaurs? It's a question often asked. **Sergio Rinland** tuned into this year's Indy 500 knowing the answer!

**ABOVE** Winning combination: Colin Chapman (left) and Jim Clark (centre) confer

**A VERY** select group of drivers in motorsport history – you could count them on the fingers of one hand – have possessed skills clearly superior to their contemporaries. Jim Clark was one of them.

Last month's Indianapolis 500 marked the 60th anniversary of Clark's victory in 'The Greatest Spectacle in Racing', achieved at his third attempt. He led in 1963, finishing a controversial second. He led again the following season, only to retire with a mechanical failure. Clark was clearly dominant on all three occasions: it could have been three from three.

The story of how Clark and Lotus came to dominate the great race is a fascinating one, of which we can perhaps just touch the tip of the iceberg.

It all started five years earlier, when 1960 World Champions John Cooper and Jack Brabham took their Cooper T53 F1 car for a test at Indianapolis, a move instigated by Indy star Roger Ward. At the time the Brickyard and the USAC championship were dominated by front-engined 'roadsters', big cars produced by local race car builders.

The majority of them were powered by four-cylinder Offenhauser engines. They developed 325 HP in those days and weighed more than 800 kg; Brabham's Cooper Climax T53 had merely 240 HP and weighed 500 kg.

The test convinced Jack and John Cooper to enter the Indy 500 in 1961 with a slightly modified T53, named T54, still with a Coventry Climax engine but enlarged to 2.7 litres, which increased the power to 268 HP. They didn't win; hence the Americans dismissed the exercise except for one man: Dan Gurney.

I had the privilege of working for Dan at the end of the GTP programme and the start of the IndyCar project with Toyota. He was one of the most complete and competitive combinations of driver and engineer in motorsport history, belonging to a select group that boasts names like Jack Brabham, Bruce McLaren and Mark Donohue.

I witnessed first-hand how he thrived on innovation and was always looking to the future. He was way ahead of the curve compared to his countrymen at the time, and not just by 'inventing' the victory champagne spraying!

Dan witnessed what Cooper and Brabham had achieved with the tiny T54. Then he saw the Lotus 25 raced by his close friend Jim Clark at Zandvoort in 1963. He was convinced that if Colin Chapman could build a stronger 25, which could handle a 4.2-litre Ford V8 being developed by the Ford Motor Company for Indianapolis, he could win the 500-mile race. He managed to persuade Chapman and broker the deal between Lotus and Ford that would make history in the years to come.

Dan and Jim were good friends and shared the Lotus attack on Indy in '63 with the Lotus 29. Jim finished second, Dan seventh. It was obvious that a rear engine was the way to go. The end of the roadster dinosaurs had begun.

For 1964 Chapman asked Dunlop to develop tyres for the Indy 500 and that was their Achilles Heel. The Dunlops were not up to the job: Clark's DNF was caused by a blown tyre breaking the left rear suspension; team-mate Gurney was foiled by extreme tyre wear. In '64 the British attack also featured Jack Brabham with a Brabham BT12 Offenhauser. The rear engine revolution was at full throttle.

With two years' experience, Team Lotus went back to Indy in '65 with a new Lotus 38 – and with Firestone tyres – determined that this time they would win it. They did.

The success of Lotus, Ford and Clark spoke volumes about the character of Gurney. He instigated the project, brokered the Lotus and Ford alliance, but he could not win the race he most wanted to win as a driver.

Yet Dan was over the moon when his friend Jimmy Clark won. I would like to see that level of sportsmanship these days in any discipline of motorsport. It was comparable only with Peter Collins handing his car to Fangio in 1956 so the Maestro could win his fourth F1 World Championship.

The 1965 Indy 500 featured only six front-engined roadsters, the first time the balance had swung in favour of rear-engined cars. But the combination of Clark, one of the greatest drivers ever to grace the sport, and Chapman, one of the best racecar designers in history, ensured that the British invasion was unstoppable.

That dominance would remain, with few interruptions, until the end of Champ Cars in 2008. By then, by way of consolation, Dan Gurney had gone on to win the Indy 500 three times as a constructor...

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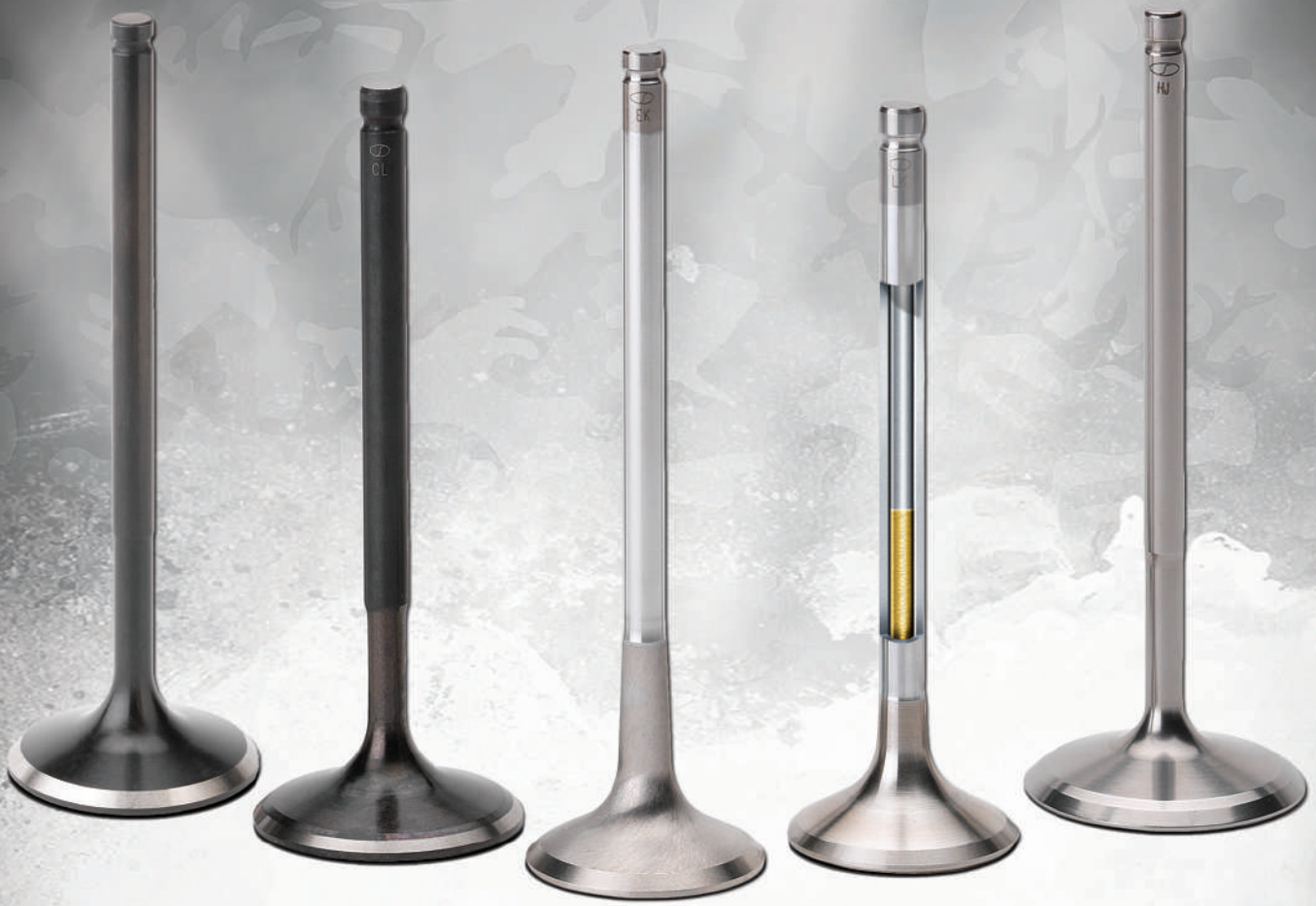

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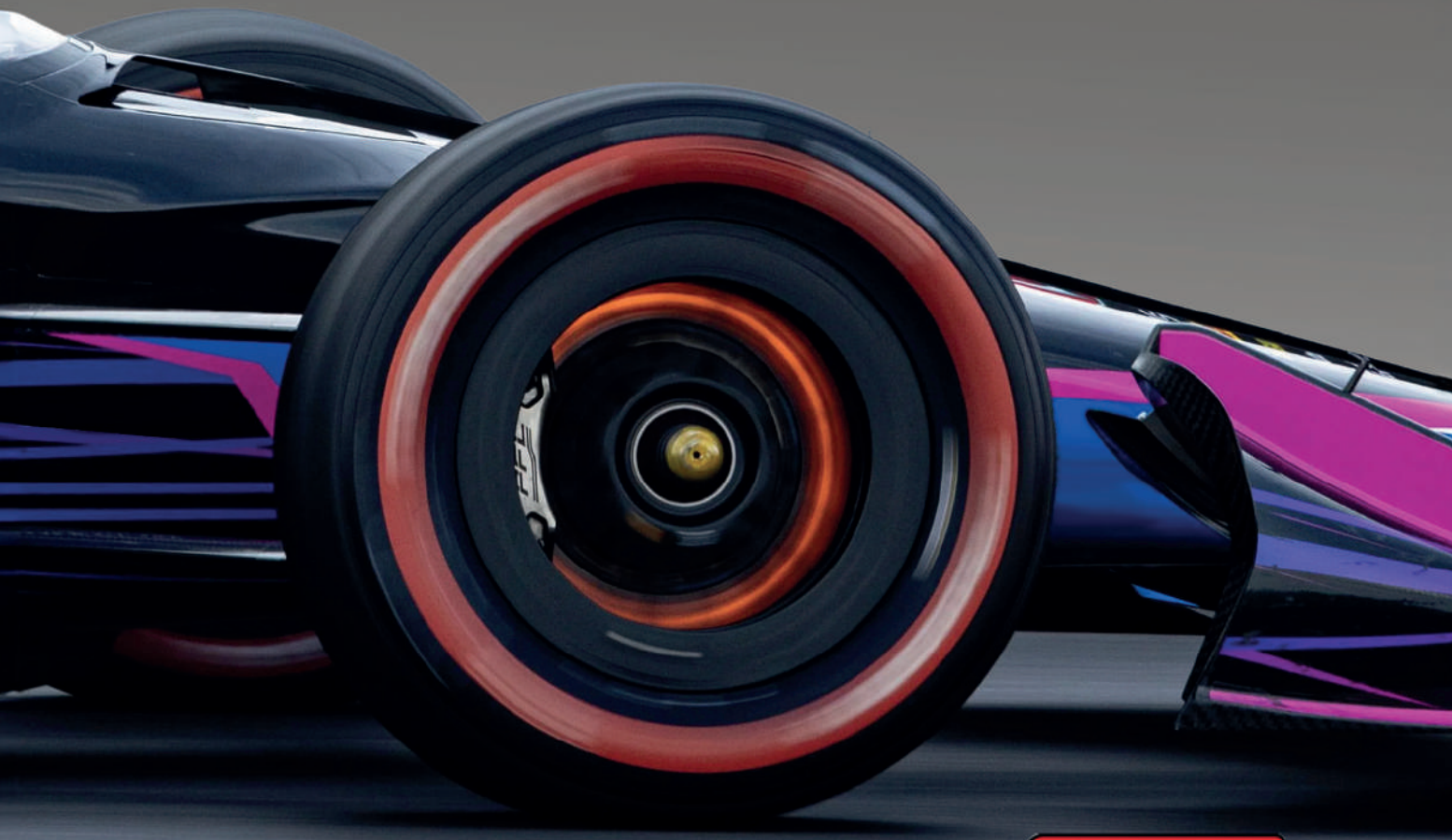

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